POWER PLANT ENGINEERING

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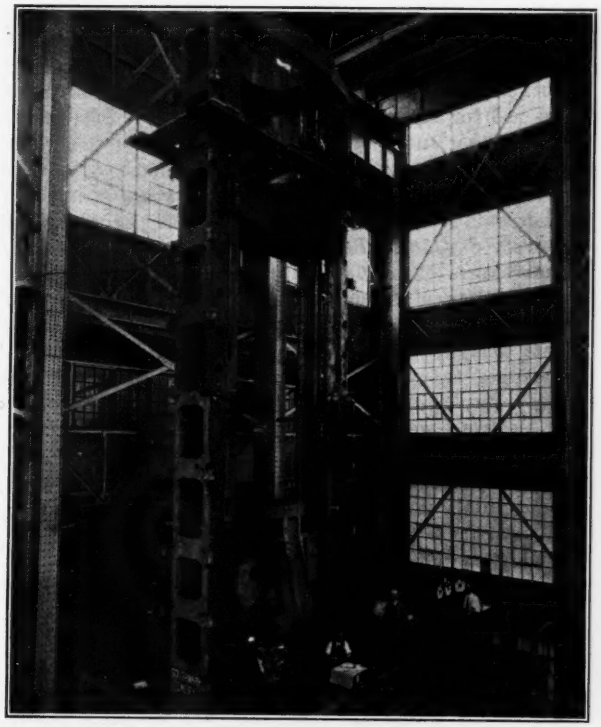

Now You Tell One

THIS IS A TALL one all right and on top of that it's going to California where test specimens grow so big and so tough that it takes a 3,000,000 or 4,000,000-lb. machine to break them. The Baldwin-Southwark Corp. built it for the University of California and had three experts take a week off to calibrate it before turning it over to Professor R. E. Davis to play with. Two of these experts were twins—this accounts for the five men in the picture.

Believe it or not, when you take to testing full sized columns up to 33 ft. 6 in. long, you've tackled a man's sized job. The machine is so tall that the upper end will, except in extremely clear weather, be hid by clouds and a system of loud speakers will be used to inform the breathless public of the progress of the test at the higher altitude.

These loud speakers will be connected with the observer's platform by a special system of ozone piping flange-connected and held together by star points. If you think that is a pipe try and make one! When you get tired, turn to page 285 and Mr. Moffett will tell you what kind of pipe flanges to use if you want any and all kinds of piping to give the best service.

And speaking of atmosphere and ozone, an article on air conditioning, page 297, may help to solve the problem of keeping air right for comfort and best manufacturing conditions in your factory.

WITH THE EDITORS

A Depression? Not in Science

From the Massachusetts Institute of Technology comes the startling announcement of a new x-ray tube to be operated at a potential of *15 million volts!* Almost at the same time the University of Chicago reports contemplated investigations into the structure of matter with a *ten* million volt tube. At Johns Hopkins there is in use for medical work a tube rated at 900,000 v. while at the Bureau of Standards a tube of 2 million volts has been used in atomic investigations.

There may be a depression in the world today but certainly it is not a depression in scientific achievement for every day, from the research centers the world over, come reports of new discoveries and developments in every branch of scientific investigation. A few years ago an x-ray tube of 250,000 v. was the limit of achievement; today we calmly regard million and two million volt tubes as everyday matters. More and more the atom is disclosing its secrets. Not content with protons and electrons we now have the neutron. Brought into prominence by recent researches at the Cavendish laboratory, this new member of the atomic family gives promise of being a new building block of the elements and one, perhaps, which is closely associated with the cosmic ray.

And, speaking of cosmic rays, from Germany comes the news that Professor Bothe produces cosmic rays artificially by the transmutation of helium and beryllium into carbon with a release of energy greater than that put into the process!

All these things are real; they are not mere brainstorms of feature writers of our Sunday supplements. Every day more and more scientific data is accumulating, in all fields, in chemistry, in physics, in biology—data infinite in its detail, marvelous in its complexity. The coordination of this data will result in new discoveries of increasing importance and consequence to the human race; indeed, we seem to be on the verge of a great era—an era of "applied atomistics," more wonderful, more revolutionary in its effect upon humanity than anything that has gone before.

Life and Service Improved by Scheduled Inspection

To forestall interruption of service by making repairs in advance of a breakdown, yet not so prematurely as to lose useful and safe service from equipment, is one of the uncertain factors that enters into the operation of a power plant. For example, how far in advance can you predict the failure of a boiler furnace wall, the opening or tearing of a belt, the corrosion of a stack or breeching, the fraying of a wire rope or cable, or the scaling of turbine blades?

Certainly all of these things do take place as a result of continued use. The life of different details of equipment varies widely, not only with the materials used and the design features, but with the surrounding conditions of service and the care and attention given to the equipment by the attendants in charge. Plant owners have a right to expect a certain length of service from the equipment which they have had installed and it is the duty of the engineer in charge so to care for and operate equipment that it will not wear or deteriorate unduly.

In all operating problems, the element of chance is always present and experience is without doubt the best guide the engineer can have but this experience must be of the type that has averted trouble, rather than caused or encountered it due to lack of foresight. Knowledge of conditions is the first requisite in the problem of plant operation and maintenance. As these conditions change with time and service, constant check is necessary in order to keep informed.

Engineers in well-operated plants have met this situation by periodic inspection and repair of equipment under their care. As soon as possible after equipment is installed, a schedule is worked out for the operator to follow including attention to lubrication, regular adjustment of moving parts, taking up on bearings, replacement of dangerously worn or corroded parts, thorough inspection, cleaning and painting. With such a schedule worked out for each piece of equipment and carefully executed under the supervision of an experienced engineer, the useful life and satisfactory operation of equipment have been greatly improved. A feature which should not be overlooked is a carefully kept record of the work done on equipment and the conditions observed so that this information is available to those responsible for operation.

Electrified Farms Are Increasing

That the conveniences of electricity are being appreciated by the farmers of the country is evidenced by the recent survey conducted by the Statistical Research Department of the N. E. L. A. which reports that, during 1931, 48,940 additional farms were added to the number already using electric service from public utility lines bringing the total number served to 698,786. This is an increase of 7.5 per cent in a year when nearly every other business was at a standstill. At no time since 1923, when the total number of farms served was 177,500, has the curve failed to point upward.

Farmers are coming to depend more and more upon machinery and appliances to do the work which has heretofore been performed by hired employes and, with the conveniences afforded by electric service around the house and farm yard, much of the disagreeable chore work has been eliminated. No class of customers is more cognizant of the value of electricity than the farmers.

Too frequently utility companies have advocated the use of electrical devices on the farm as conveniences rather than money makers. It must be recognized that farm implements must pay a profit on the investment, the same as any factory equipment, or they cannot be expected to find a market among farmers. What the farmer is interested in is how he can make electric service and equipment pay for itself. When the utilities can answer this question very few farms will be without electric service.

Suggestions for Profitable Reading

How's Your Squeezing Technique?

Can you fill a large basket with air and squeeze it hard enough—the air, not the basket—so that all the moisture will fall out of the air onto the floor? Of course, it's well to do this on a concrete floor or in some convenient place where there is a drain, because you'll be surprised at the amount of water that can be squeezed out of an ordinary bushel basketful of air. After you have dried the air, however, it is splendid for use in ventilating systems, pneumatic tools and the like. When you become proficient in drying air by this method you will never use any other.

In case you want to polish up your squeezing-moisture-from-the-air technique, study of the article on compressors for air conditioning, in this issue, will help you. This tells about the methods used in an air conditioning plant at a South African mine for squeezing moisture out of the air used for mine ventilation and air tools. The air is compressed to about 40 lb., then cooled, after which the moisture precipitates and then the air expands in an air turbine to atmospheric pressure. In this expansion, the air cools to 32 deg. F. and power developed helps drive the air compressor.

Doing It Better With Better Gas

Perhaps you have become so hardened to the effects of air at "elevated" temperatures that you believe you can do it better with gas. (Pardon us just a minute while we make a note to get the details on the temperature elevator so we can describe it to you in a future issue.) Returning to the subject of gas, you will find in this issue complete details of the new West End Gas Plant of the Public Service Electric and Gas Co., at Jersey City. This plant incorporates the latest equipment and practice in gas manufacture and it is natural that the new boiler plant and turbine-driven gas compressor plant built by United Engineers & Constructors should be of interest to power engineers. An unusual feature of the plant is the installation of the condensers outdoors, a procedure fully explained in the article.

No, That Is Not George Bernard Shaw's Scratch Pad

When you first glanced at pages 299 and 300 of this issue you probably thought it was and wondered why this serious-minded journal contained an article on how to analyze great men by the scribblings on their desk blotters. Well, it's much more important than scribbling and you musn't let appearances deceive you.

To make a long story longer, electrical engineers are funny. They all admit it, so we're not insulting them. You will often see an electrical engineer sitting at his desk drawing little triangles with arrowheads on the lines and, beside these, diagrams that look like butterflies. Then, after much sliding back and forth of the slide rule and much figuring with log tables and measuring on these queer diagrams, this funny man leans back in his chair and announces that if you have sense enough to put a 300-kv-a. synchronous motor on that air compressor, you'll save some 200 kw-hr. a day.

Well, the funny part of it is that if you go and do it you find he's right. Of course, there must be something to these strange pictures, called vector diagrams because, with their help, electrical engineers, with an almost supernatural accuracy, predict in advance just what a piece of electrical equipment will do. Nor are these funny electrical engineers Scotch with their information. Mr. Stivender, a good friend of ours and yours, explains clearly in this issue some of the uses of these magic pictures. His method of explaining phase rotation is excellent and if you have a couple of generators in your power plant you can unquestionably use some of his diagrams to good advantage. In fact, if you don't already know how to use vectors in solving your electrical problems, these funny electrical engineers are only too glad to help you learn.

On Making and Eating High Grade Smoke

If the electrical engineer's vector diagrams are puzzling, just consider the plight of two electrical engineers, Messrs. Simon and Kron, of the Tennessee Coal, Iron and Railroad Co., who couldn't make the right kind of smoke. They wanted lots of smoke to test an electrostatic precipitator and they had to be able to produce a steady stream of No. 1 or No. 2 or No. 3 smoke whenever they wanted it. It was suggested that they consult the editorial department of Power Plant Engineering, some of whom are pipe smokers of rare smoke-producing ability. This was not good enough, however, because they had to have even more and blacker smoke than an editor can make.

It is ironical that all the high-powered combustion engineers have to accept the help of the electrical boys in eliminating smoke. For some time, the latter have been able to clean flue gas with the electrostatic precipitator, fundamentally nothing but an old-fashioned spark wireless outfit in a pipe or casing. But it sure does eat up the smoke and on page 299 you will find all the details of the tests that Messrs. Simon and Kron made on one of them. Don't forget, however, that if you ever get into trouble with the smoke inspector you might try this story of the difficulty of making smoke.

Speaking of Pipes—Briar or Brass—Their Color Is Important

If you think it isn't, ask one of these professional pipe smokers who has a pipe for every day of the week, a meerschaum for Sunday and special pipes for smoking outdoors. He'll show you that you certainly can tell a great deal about a pipe by its color as well as by its taste and smell. So it is in power plants and industrial plants. Many engineers maintain that piping painted and marked so that the material carried by the pipe can be identified at a glance is one of the most important aids to convenient and safe operation. One scheme has been developed by the A. S. M. E. and on page 294 of this issue you will find other valuable data on the colors, symbols and paints to use on all industrial piping as well as in the power plant.

POWER PLANT ENGINEERING April 1 1932

New Compressor Station for Jersey City Gas Plant

New Gas Compressor Station at the West End Gas Works of the Public Service Electric & Gas Company provided with turbine-driven centrifugal compressors designed for operation on 350 lb. steam pressure. This is an excellent example of modern compressor station design.

By GEORGE ESHERICK, JR.
United Engineers & Constructors Inc.

AT THE WEST END Gas Works of the Public Service Electric and Gas Co. at Jersey City, N. J., a new gas compressor plant has been erected and placed in operation recently by the Newark Branch of the United Engineers and Constructors, Inc. This new compressor station will handle the increasing load in and to the north of the Hudson Division of the Public Service Electric & Gas Co., and replaces the present compressor plant which has been in operation since April, 1910. Naturally, the project was designed to meet the requirements set up by the Gas department of the Public Service Electric and Gas Co. It has the added facility of pumping gas back to the company's plant at Harrison, N. J., as occasion requires.

While a plant of this kind differs somewhat in its purpose from the usual power plant described in these pages, insofar as the steam end is concerned there is considerable similarity between this and an electric generating plant. Here instead of the turbines driving electric generators, they drive rotary gas compressors. From this standpoint, therefore, the plant should be of interest to power plant engineers generally.

As may be seen from the photographs, the building is attractively and substantially constructed of concrete, steel and brick, amply lighted by windows on all sides, and set solidly on a foundation consisting of 200—35 ft. piles. This compressor house is entirely separate from the boiler plant which is located across the street. The operating floor is approximately 12 ft. above grade and the basement 8 ft. below grade, being designed to provide ample clearance for all of the piping—gas, water, steam and exhaust. Three turbine driven centrifugal gas compressors are installed. These are set on foundations 20 ft. high, which in turn stand on the concrete mat capping the piles. To provide maximum illumination, the interior is finished in white on the operating floor. A 10-ton hand operated overhead crane is provided for handling machinery in the compressor room.

The three centrifugal gas compressors which comprise the principal equipment are of the single flow, 3 stage type, manufactured by the Ingersoll-Rand Company, and are driven by Moore turbines, now operating at 125-lb. steam pressure. For economic reasons, these turbines have been designed to operate on 350-lb. 100-deg. superheat steam for future operation by merely

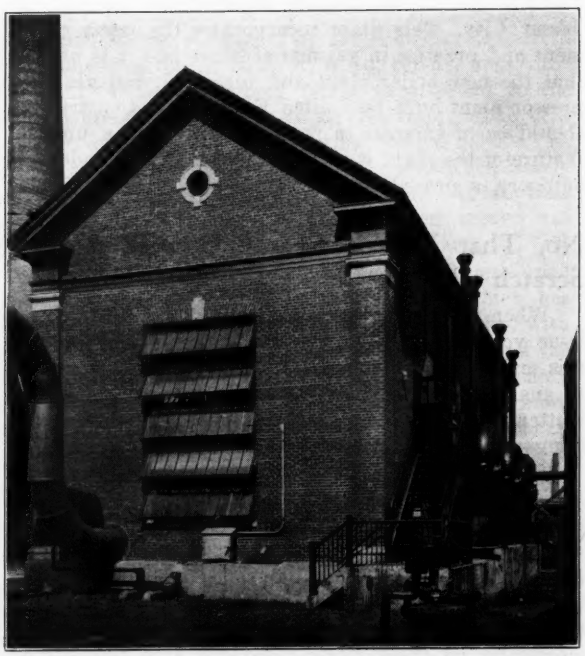

FIG. 1. AN EXTERIOR VIEW OF THE NEW WEST END GAS PLANT COMPRESSOR HOUSE, SHOWING OUTDOOR CONDENSER INSTALLATION

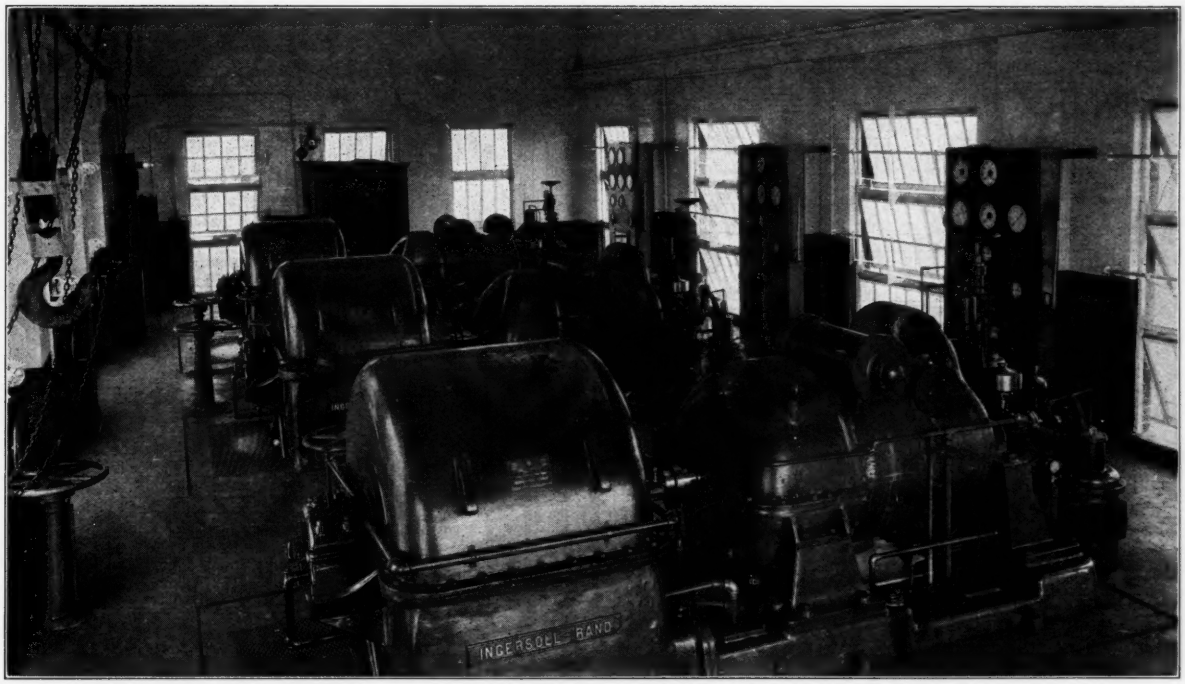

FIG. 2. OPERATING MACHINE FLOOR, SHOWING MIXED PRESSURE EXTRACTION TURBINE COMPRESSOR UNITS

making some minor changes in the turbine wheels. At the present time the machines are supplied with steam from the old boiler plant which served the old compressor house. This boiler plant will be replaced in the near future by a new high pressure plant and then the compressors will operate at the higher pressure.

The turbines are of the mixed pressure extraction type arranged at present so that steam can be either extracted from or admitted to the turbine at 10-lb. pressure. In the future, when the plant changes to 350-lb. operation steam will be extracted from the turbines at 125 lb. and either extracted or admitted to the turbines at 15 lb. pressure.

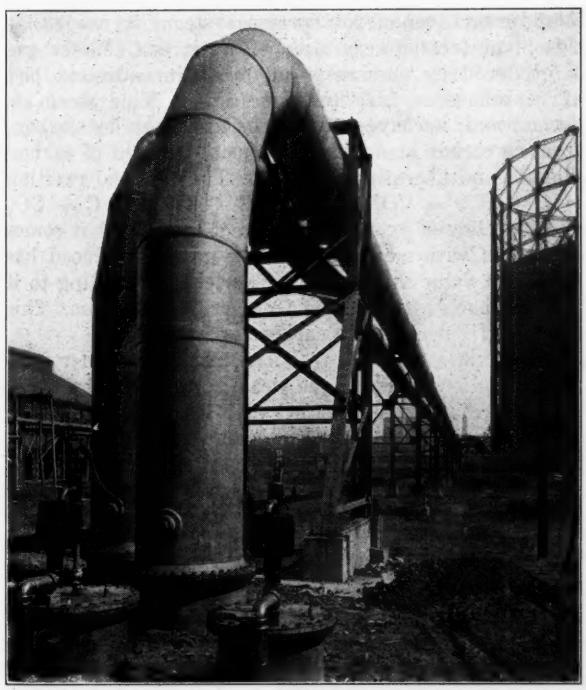

FIG. 3. NEW 42 AND 48-IN. OVERHEAD WELDED GAS MAINS

Normally, the turbines will operate condensing with about 28 in. of vacuum, but they may also be run non-condensing. They have been designed for full automatic gas and steam pressure control both for present and future operation. Each turbine has a capacity of 1480 b. hp.

Salt water is used for condensing purposes. This is pumped from the Hackensack River nearby to three Schutte & Koerting multi-jet condensers. All the water passes through a Rotrex revolving screen before entering the jet condensers. An interesting feature of the condenser installation is that the condensers are placed on the outside of the building so that the building may be kept dry and clean and also to permit a better arrangement of the piping. The three condensers can be seen in the photograph, Fig. 1, mounted on a concrete foundation along one side of the building.

The arrangement of the equipment and piping is shown in the accompanying drawings. The three compressor units are placed side by side with room for three gas exhausters at one end. At present only one exhauster is installed, this also being an Ingersoll-Rand unit driven by a Moore turbine exhausting at 10 lb. back pressure. Future exhausters will be added as the load demands.

Throughout, the piping has been designed so that exhaust steam from the plant auxiliaries will be available to the main turbines for greater economy. These turbines are now being operated by exhaust steam that has heretofore been lost to the atmosphere.

Automatic control of the steam is provided so that steam may be taken from the turbines at 10 lb. or may be fed to them at that pressure according to the demand,

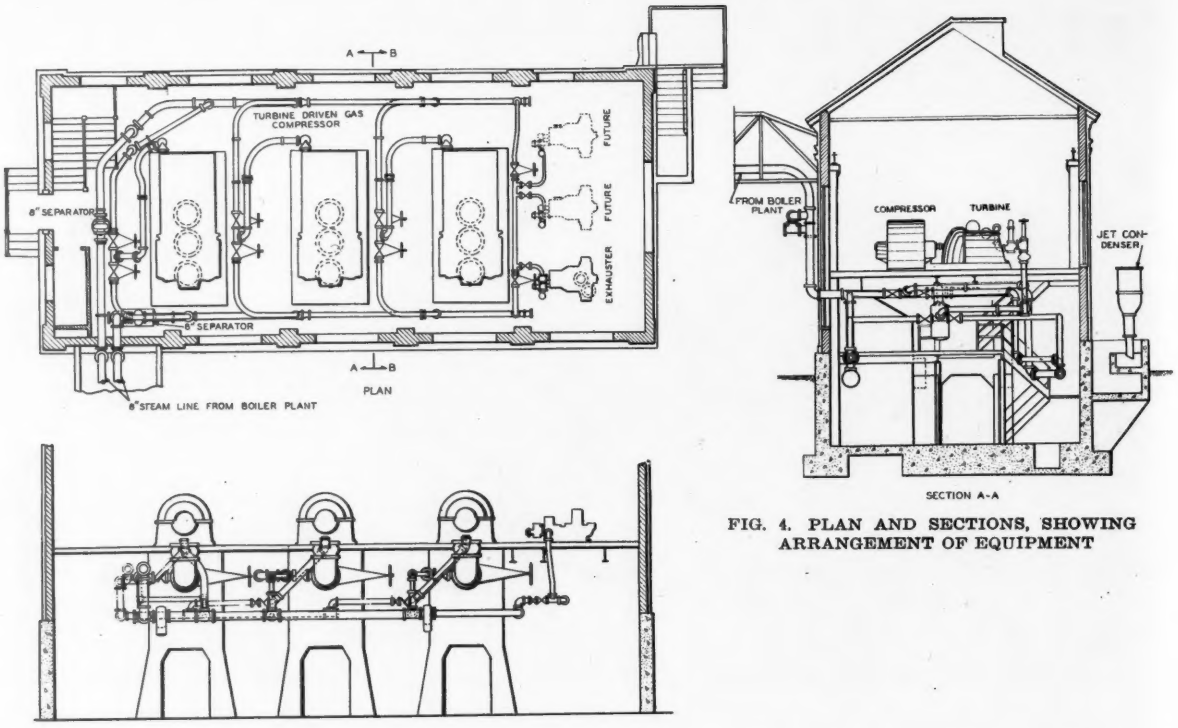

FIG. 4. PLAN AND SECTIONS, SHOWING ARRANGEMENT OF EQUIPMENT

the steam pressure being held constant in the 10-lb. line by the turbine. The balance is maintained by steam entering the turbine via the high pressure governors as called for by the gas pressure regulators. These governors are actuated by less than one-quarter of a pound variation in the gas pressure discharged from these compressors.

In the future, 125-lb. steam will be extracted from the turbines for auxiliaries of the plant and at that time the sensitive control of steam to and from the turbines will be maintained at the 15-lb. point.

The high pressure steam piping is arranged to afford maximum reliability, consistent of course, with ease of operation and accessibility. Two 8-in. steam mains from the boiler plant supply a looped header system with three crossover connectors, one feeding each turbine. The header leading to each turbine is connected to the crossover line between two valves, so that the turbine can be supplied from either or both sides of the steam loop. An 8-in. steam separator is installed in each of the main steam lines from the boiler plant.

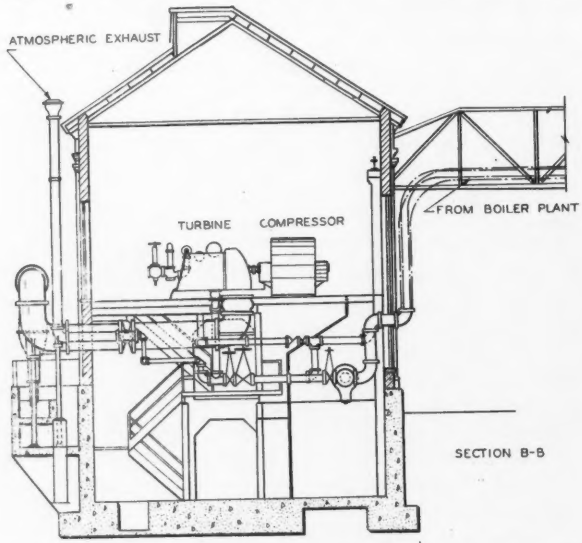

FIG. 5. SECTION SHOWING TURBINE EXHAUST AND BLEED STEAM PIPING

Steam Accumulator Maintains Uniform Flow of Steam to Generators

A great deal of low pressure steam is needed at this plant for the generation of water gas. Water gas is produced by passing steam to an incandescent bed of carbonaceous fuel (coke or coal). This steam is decomposed, its oxygen being seized by the hot carbon, forming carbon monoxide and a small amount of carbon dioxide, and liberating hydrogen. The chemical reaction is $C + H_2O = CO + H_2$ or $2C + 2H_2O = C + CO_2 + 2H_2$ followed by a splitting up of the CO_2 as it comes in contact with more carbon. The gas so produced has little heat value so it is further enriched by adding to it hydrocarbon gases obtained from crude petroleum. This enriching is done in the carburetor.

Since these chemical reactions take place under comparatively low pressure, the steam supplied to the water gas generators is maintained at 5-lb. gage. To assure an even flow, a Smoot steam accumulator has been provided. This not only maintains a constant steam pressure to the generators but also acts as a storage reservoir for heat between the generators and the turbines.

Gas Compressors Have Capacity of 1,500,000 Cu. Ft. per Hr.

The gas compressors have a normal capacity of 1,500,000 cu. ft. per hr., and a maximum overload rating of 2,000,000 cu. ft. per hr. at 7½-lb. pressure. To handle the gas from the gas holders and to the system, two

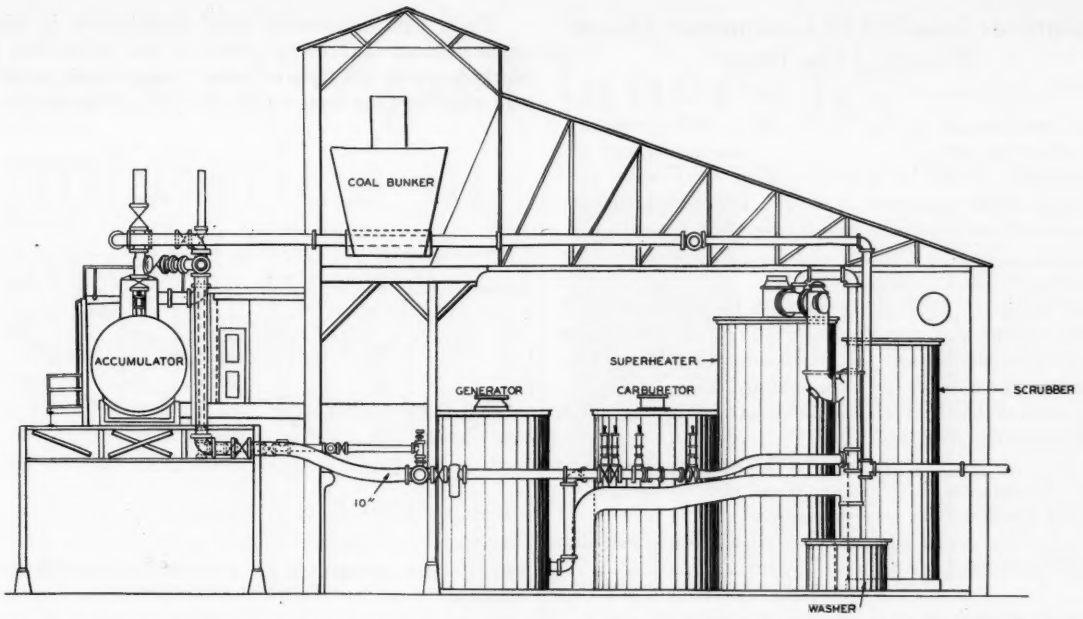

FIG. 6. SECTION OF GENERATOR HOUSE SHOWING NEW STEAM ACCUMULATOR AND ASSOCIATED PIPING

overhead gas mains were installed. These lines, shown in Fig. 3, are made of welded steel pipe, 42 in. and 48 in. in diameter. The piping work throughout both on the gas and steam sides is of the most excellent character.

High-pressure steam piping has been installed to permit the greatest flexibility in operation at the time of installation of the high pressure system. As the plant piping is now arranged, the high-pressure system can be installed without interruption to the normal operation of the plant. A permanent bridge has been erected across Duffield Avenue to the boiler plant to carry this piping.

Indicating and recording instruments have been provided on each compressor unit to keep a continuous record of all plant operations. A separate gage board is provided for each unit. These show the flow of 125 lb. steam, gas flow and condensing water flow. The amount of steam is also recorded to show the quantity delivered to the unit, or the quantity taken from it at the 10 lb. exhaust pressure. This quantity depends on the demand for 10 lb. steam required for gas making. The indicating and recording instruments were furnished by the Republic Flow Meter Co. and are of the electric type.

Lubricating Oil System

The lubricating oil system is unique in that oil is put into the system on the outside of the building. Storage tanks are located in the basement where a Westfalia oil separator, a totally enclosed type, has also been installed with motor and circulating pumps as part of the machine. This system is shown in Fig. 8. Piping has been arranged for maximum flexibility so that oil from any or all machines can be continuously cleaned and recirculated, without interfering with carrying of the load. This also has been arranged so that by

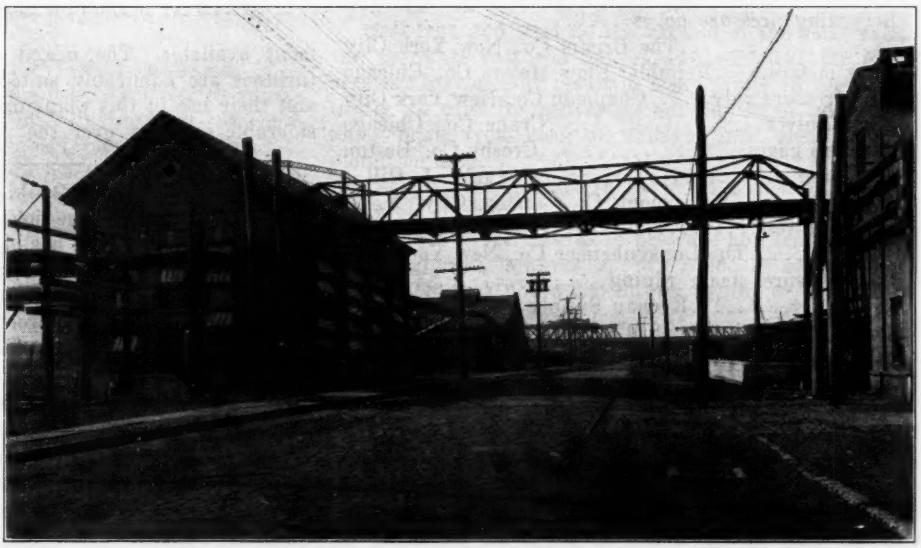

FIG. 7. A PERMANENT BRIDGE CARRIES HIGH PRESSURE STEAM LINES FROM OLD BOILER PLANT AT THE RIGHT TO THE NEW COMPRESSOR HOUSE

Equipment Installed in Compressor House West End Gas Plant

3 Gas compressors driven by Moore mixed pressure extraction turbines.....Ingersoll-Rand Co.
1 Exhauster driven by Moore turbine, exhausting at 10 lb. back pressure.....Ingersoll-Rand Co.
Steam accumulator and regulating valves.....
.....Smoot Engineering Corp., New York City
Interior finish Craftex.
Roofing.....M. H. Donovan & Co., Newark, N. J.
Steam traps .....Strong
High pressure piping..M. W. Kellogg Co., Jersey City
Turbine for circulating water pump.....
..DeLaval Steam Turbine Company, Trenton, N. J.
Oil purifier—Westfalia .....
.....L. R. Merritt & Co., New York City
Pipe covering.....Chas. S. Wood Co., Newark, N. J.
1 18-in. vertical back pressure valve.....
.....Cochrane Sales Co., New York City
1 12-in. vertical back pressure valve.....
.....Cochrane Sales Co., New York City
1 8-in. vertical back pressure valve.....
.....Cochrane Sales Co., New York City
4 10-in. oil separators.....
.....Cochrane Sales Co., New York City
12-in. Vapor cushion type multiport back pressure valve.....Cochrane Sales Co., New York City
12-in. Check valves..Cochrane Sales Co., New York City
Condenser water piping.....
...Lynchburg Foundry Company, Lynchburg, Va.
Steel.....Selbach-Meyer Co., Jersey City, N. J.
Floor finish.....A. C. Horn Co.—Specifications by Geo. Peterson, Inc., Harrison, New Jersey
Overhead pipe welding.....
.....Hutton Welding Co., Jersey City, N. J.
Piles...Linde-Griffith Construction Co., Newark, N. J.
10-Ton crane (hand operated).....
.....Box Crane & Hoist Corp., Philadelphia
Steel sash.....Metal Windows, Inc., Newark, N. J.
3 Jet condensers...Schutte & Koerting Co., Philadelphia
1 Rotrex strainer.....Andale Company, Andale, Pa.
3 10-in. Atmospheric relief valves.....
.....Atwood & Morrill, New York City
Recording pressure gages.....
.....The Bristol Co., New York City
Flow meters.....Republic Flow Meters Co., Chicago
Low pressure valves....Chapman Co., New York City
Small valves.....Crane Co., Chicago
Pressure gages.....Crosby Co., Boston
Plumbing.....M. J. Gill
Engineering Equipment Co., Jersey City, N. J.
Small valves .....
.....The Lunkenheimer Co., New York City
Low-pressure steam piping.....
.....Keenan Supply Co., Philadelphia
Overhead pipe lines—48, 42 and 36-in.....
...Pennsylvania Furnace & Iron Co., Philadelphia

the mere closing or opening of segregating valves, the oil from any turbine may be drained, cleaned, placed in storage, or returned to the machine base without loss of oil on the floor or overboard. The separator is a compact and efficient unit.

From this necessarily brief description, it will be quite evident that every detail of this plant has been worked out on the basis of sound engineering principles and that use has been made of the most modern equipment available. The mixed pressure extraction type turbines are admirably suited to this class of service and their use in this plant undoubtedly will show considerable economy over the plant which this replaces.

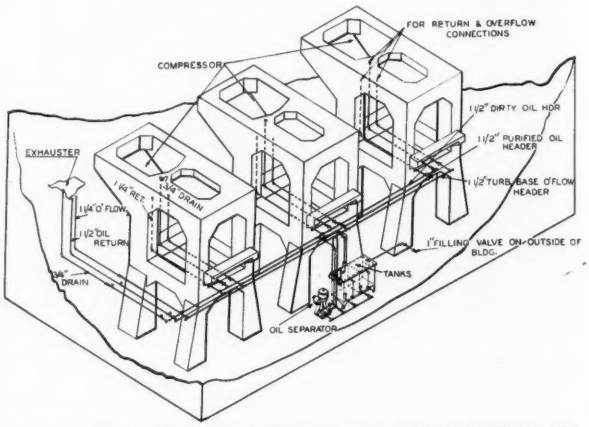

FIG. 8. ARRANGEMENT OF TURBINE LUBRICATING OIL PURIFYING SYSTEM

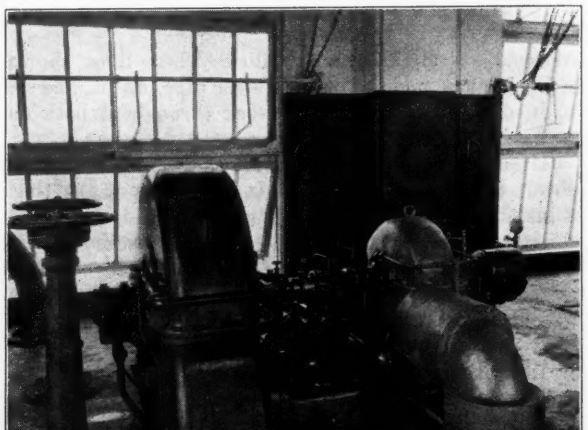

FIG. 9. TURBINE DRIVEN GAS EXHAUSTERS, EXHAUST STEAM AT 10 LB. FOR USE IN MAIN TURBINES

In construction of Boulder Dam, compressed air is largely used and, as the job is scheduled to take 6½ yr., long life equipment has been provided. Compressor intakes are provided with Annis air filters of dry type in multiples of 100 c.f.m. capacity, having wool felt filtering elements on rust-proof wire frames, mounted in rust-proof metal housings. They are claimed to cause pressure drop of only 3/16 in. water and to be cleanable in place by blowing off with an air hose.

Dusts are dangerous. Of those not poisonous in the usual sense, silicious dusts are most dangerous because they produce silicosis, by their effect on the lungs.—Chemical Digest.

Types of Pipe Flanges for Application in Power Plants*

By HENRY C. MOFFETT

INCREASING PRESSURES AND TEMPERATURES HAVE BROUGHT ABOUT THE DESIGN OF MANY TYPES OF FLANGES, SEVERAL OF WHICH HAVE BECOME STANDARD

Henry C. Moffett, Consulting Piping Engineer, Jackson, Mich., was graduated from the School of Mines, Columbia University, New York City in 1912. For several years, mining engineering in California, Arizona and Mexico occupied his time and later he was engaged in power plant design, principally piping layouts, for plants in Texas and Michigan. Between 1918 and 1921 his services were engaged by a boiler manufacturer for purchasing and production work. Management, design and construction for a Chicago oil refining company took his attention between 1922 and 1925 when he assumed charge of piping design for the Commonwealth Power Corp., Jackson, Mich. As sales engineer with offices at Detroit, he represented Pittsburgh Piping & Equipment Co. from 1927 to 1931 and on three different occasions, and until recently, he was connected with the Fargo Engineering Co., Jackson, Mich. Mr. Moffett has been engaged to prepare for exclusive use in Power Plant Engineering, a number of articles, of which this is the first, on the general subject of power plant piping design and practice. The others will appear in succeeding issues.

ENGINEERS do not always agree about the selection of suitable flanges for any given service in piping practice. This selection is, nevertheless, an important problem and must be solved for each system of piping whenever a design is called for. The proper selection of flanges becomes more and more important as the pressures increase and the temperatures rise.

Standards have been established which are a great help to designers, and wherever possible these should be used. Bulletins are published by the American Standards Association, 29 West 39th St., New York City, which cover in detail the adopted standards as to sizes, pressure ratings, markings and the strength of materials, for both cast-iron and cast-steel flanges. These standards also cover all details for drilling, facings, bolting materials, spot facing, metal thicknesses and dimensions, and are called respectively, "American Standard Cast-Iron Pipe Flanges and Flanged Fittings," and "Tentative American Standard Steel Pipe Flanges and Flanged Fittings."

All engineers and designers engaged in piping design should have these standards for reference. These bulletins are the result of long and painstaking effort on the part of engineering societies and manufacturers to evolve a pattern for standard practice, and while some changes are still being made, these represent the consensus of opinion as to what is considered the best practice today.

The American Society for Testing Materials, 1315 Spruce St., Philadelphia, publish Standard Specifications, which are often used as references by engineers in writing piping specifications for any particular job. These standard specifications contain guides for the method of manufacture, chemical properties and tests, physical properties and tests, workmanship and finish, marking, and inspection and rejection clauses. Goods specified and manufactured under these standards are of known quality. All reliable concerns abide strictly by the terms set forth in them whenever called for, and many manufacturers use them as guides whether called for or not.

Other considerations come into the selection of flanges, however, which are not standardized. The more severe the service becomes, the more these special considerations come into prominence. The improving and cheapening of stronger and better materials has also had an influence in the choice of flanges of somewhat better grade than called for in the standards.

Cast-iron screwed flanges for low-pressure and vacuum lines, have long been standard practice, yet some engineers and not a few industrial executives are insisting on forged or rolled steel flanges for these services, now that the cost of manufacture has been lowered to nearly that of cast-iron flanges. The main reason for this is that forged steel or rolled steel flanges rarely if ever break during shipment or in service.

Of late years some of the best shops have developed a cast iron which has a tensile strength of 30,000 lb. per sq. in. or higher, whereas 24,000 lb. per sq. in. is the highest called for in the standards, as minimum for heavy castings. Not many years ago this was about the highest strength to be expected from cast iron in flanges and fittings. This new higher strength cast iron has a finer grain structure, hence, when faced off, the gasket bearing surface is smoother and will therefore make up a tighter joint in service. The old style cast iron is now rarely used in high class power plant work.

Cast iron and steel do not expand at the same rate, and therefore cast-iron flanges on steel pipes for temperature service may result in leaky joints. Since practically all pipe for conveying hot liquids or gases are today made from steel or wrought iron, steel flanges should be used.

Cast-steel flanges are in favor with some engineers and great quantities of them have been used where the service was severe both as to pressure and temperature. Most engineers, however, specify rolled or forged steel flanges for work above 250 lb. per sq. in., or where the temperature exceeds 700 deg. F.

In the following paragraphs some of the many types of flanges in common use today will be discussed.

PLAIN AND RAISED FACE FLANGES OF THE SCREWED TYPE

Screwed flanges, plain face, Fig. 1, are known as 125-lb. standard. The maximum working saturated steam pressure allowed is 125 lb. per sq. in. (gage), but for non-shock hydraulic pressure may be used for as

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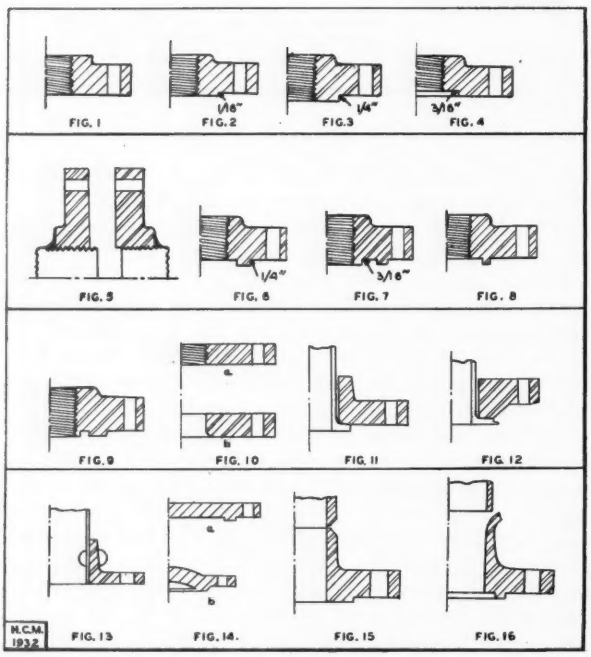
high as 175 lb. per sq. in. in cast iron. Flanges of this type may be had in cast iron, cast steel, or cast semi-steel, and rolled or forged steel.

Screwed flanges, 1/16 in. raised face, Fig. 2, are known as 250-lb. standard. The 1/16 in. raised face is included in the minimum flange thicknesses, as given in the standard tables referred to above, and should remain after refacing in the shop when the flange is made on to the pipe. Although some cast-iron flanges of this type are in use, they are not to be recommended for steam piping. The maximum working steam pressure rating at 750 deg. F. is 250 lb. per sq. in.; the maximum hydraulic rating at ordinary temperatures, is 500 lb. per sq. in. when the material used is a high grade carbon steel with a minimum tensile strength of 70,000 lb. per sq. in.

Screwed flanges, large male face, Fig. 3, have male raised faces ¼ in. in height. These faces are not included



PIPE FLANGES IN COMMON USE

1. Plain face, screwed. 2. Raised face, screwed. 3. Large male face. 4. Large female face. 5. Small male face and small female face. 6. Large tongue. 7. Large groove. 8. Small tongue. 9. Small groove. 10. No hub ring. 11. Van Stone. 12. Sargol or Sarlun. 13. Spiral pipe flange. 14. Blind. 15. Standard for welding. 16. Forge and Hammer lap welded.

in the minimum flange thicknesses as given in the standard tables. Flanges of this kind are used principally for pressures above 250 lb. per sq. in. The outside diameter of the raised face is the same for all pressures, but the width of these faces depends upon the bore of the pipe.

Flanges for 400-lb. service, and above, of this type are frequently welded at the back, to seal against leakage along the threads.

Screwed flanges, large female face, Fig. 4, have faces with depressions 3/16 in. deep, the diameters of which are 1/16 in. greater than the corresponding male face. Joints made with male and female flanges are sometimes troublesome to match up, especially if some of the flanges are cast as a part of the fittings. The recess, however, acts as a retainer for the gasket, and blow-outs are minimized.

Screwed flanges, small male face, Fig. 5, left, and small female face, Fig. 5, right, have the advantage of greater gasket pressure for the same bolt stress. For some classes of high-pressure work this kind of flange is ideal, especially on small pipe sizes, since the gaskets may bear directly on the pipe ends.

Joints made up with small male and female face flanges experience little or no leakage troubles up to 900 lb. per sq. in. Gaskets should, however, cover the entire bearing surface with minimum clearance. Unless the pipe wall is thick enough to insure full gasket size, there is a possibility that gaskets will be crushed.

Screwed flanges, large tongue, Fig. 6, are not as commonly used as the male and female type, since greater care must be exercised to have gaskets bear equally all around. This requires delicate lining up. These joints, however, have the advantage of being easier to disassemble. Tongues are always ¼ in. high.

Screwed flanges, large groove, Fig. 7, have grooves 3/16 in. deep; their diameters 1/16 in. greater than the corresponding tongues. Joints made up with large tongue and groove flanges have higher gasket pressures than the large male and female for an equal pull on the bolts and therefore metallic or metal clad gaskets are used, so as to prevent crushing or squeezing out. This type of joint will hold tight under great pressures and is especially satisfactory when temperatures are low. Frequent changes of temperature may cause leaks to occur.

Screwed flanges, small tongue, Fig. 8, are more frequently specified for pipe sizes under 3 in., and for pressures above 400 lb. per sq. in. In the higher pressure range, flange thicknesses are sometimes increased above the standards, in order to prevent distortion of the flange facing when drawn up tight.

Extreme gasket pressures are realized with this type of flange, hence tight joints are maintained at high pressures. Some engineers specify soft steel gaskets, such as Swedish iron. Others prefer monel metal or other alloys.

Screwed flanges, small groove, Fig. 9, represent a type of which there are many special designs. Some are beveled for welding at the back. Others are recessed so the pipe when threaded on does not project to the face of the flange, but butts against a smooth bearing surface faced off on the inside of the flange. Small tongue and groove joints are favored by most engineers for high-pressure hydraulic work.

Ring flanges, no hub, Fig. 10, are made from either rolled or forged steel as a rule, or may be simply cut out from steel plates. In the smaller sizes they are most frequently threaded with straight locknut threads, and welded at the back to seal against leakage along the threads. A satisfactory joint may be made using ring flanges, one flange threaded so that the pipe end projects 3/16 in., the other so that it leaves a recess ⅛ in. deep.

Van Stone flanges, Fig. 11, are used whenever a lap is turned on the end of a pipe, and are designed to bear directly on the backs of the laps. These flanges are loose on the pipes, and therefore may be turned at any angle when making up a joint. This is a great advantage in lining up bolt holes. These flanges usually have a bore ⅛ in. larger than the outside diameter of the pipe to which they are fitted.

Van Stone flange designs vary from high hub to no hub depending on the standard and the whim of the

designer. High hubs are used for greater strength, usually on sizes above 3 in.

Sargol flanges, Fig. 12, have no hubs, but have fillets on the sides nearest the laps of the pipe. This is to spread the flanges farther apart so that the turned laps of the pipe may be accessible for welding. In all other respects Sargol flanges are the same as Van Stone flanges.

Sargol flanges which are cast as a part of fittings have special welding tips as a part of the raised face. These as well as the special welding tips on the turned laps of the pipes are welded after the joints are made tight, without the use of gaskets. The contact faces must therefore be accurately ground, and any unevenness removed by the use of face plates, or finish polishing under water.

Sarlun flanges, Fig. 12, are almost the same as Sargol flanges; the shape of the welding tip is about all that differentiates them. The welding of the tips is a patented feature of both of these joints. The welding tip of the newer Sarlun flange is longer and thinner; the welding process therefore is less apt to distort the face. The weld itself does not add any strength to the joint; it is for sealing only.

Spiral pipe flanges, Fig. 13, are usually riveted on and unless ordered with A.S.A. Standard flanges, all spiral pipe will be fitted with standard riveted pipe flanges by the fabricator. These are somewhat lighter in section than the A.S.A. flanges in general use on ordinary steel pipe, and are riveted onto the pipes as ordered.

Regular riveted pipe flanges are made of forged and rolled steel. These regular flanges are smaller in outside diameter and are drilled for bolting on a smaller bolt circle than the A.S.A. Standard. Most riveted pipe manufacturers use what is known as the spiral pipe standard drilling.

Blind flanges, Fig. 14, are customarily used whenever it is necessary to blank off the end of a pipe line for future extensions or for the removal of valves. Some of these are flat circular disks drilled to match the standard bolt circles. Such flanges are used when the pressure is low, except for sizes above 12 in.

Above 12 in. for low-pressure work, or above 10 in. for 250 lb. work, flanges are usually dished, the radius of the dish made equal to the diameter of the port.

Standard flanges of steel for welding, Fig. 15, have recently been introduced. These have the same bore as the pipes to which they are to be welded, and have the welding edges machine beveled at 45 deg.

Flanges of this type must be carefully tack welded in order to secure true alinement, before the final continuous weld is made. Welding rod is available for this purpose, which when used according to instructions will make a very satisfactory job.

Forge and hammer lap welded flanges, Fig. 16, are welded directly to the pipe ends without the use of welding rods. The edges of the plates are lapped over each other without scarfing. After heating to the proper point for welding, the joint is welded with hammer blows, which flows the metal under welding temperature. The welded joint is then annealed. Due to the nature of this weld, all work must be done in the shop.

Flange protectors are put on in the shop for the purpose of avoiding the scratching or nicking of flange facings, which have been carefully machined or ground. These may be either wood or cast iron, depending on the kind of flange that is to be protected.

Cast-iron flanges are rarely fitted with them. Turned laps on Van Stone joints are usually protected during shipment, especially if the shipment is by rail. Wooden protectors are the rule.

Ground faces on Sargol or Sarlun flanges should always be fitted with cast-iron protectors, using a soft material or gasket, well greased, between the face and the protector.

Fish Elevators at Baker River Dam

SALMON climb ladders and ride in elevators to the top of the 253-ft. Baker River Dam, in Washington, thus surpassing previous accomplishments of the Reclamation Service which has built fishways around all the dams it has built in the salmon streams of the Northwest.

In traveling downstream a salmon merely allows the current to carry him along, but in going upstream when returning to the spawning grounds, he often finds barriers that he must take. Fish ladders have been in use for several years in these northwestern streams to aid the salmon in their upward climb. A height of 50 ft. had long been accepted in the Northwest as the limit to which salmon would climb up a fish ladder on their way to the spawning grounds. Since the Baker River Dam is 263 ft. high, something had to be done or an industry important to that section would be destroyed.

A scheme of trapping each step in a fish ladder against the return of the fish downstream was devised. The theory is that when the fish gets tired or discouraged it will not be carried downstream by the current but is trapped at the point where it happens to be until it is ready to proceed. The most important element in the scheme is the curved finger-like rods which are placed at each 2-ft. drop of the ladder, constituting a guard or trap which prevents a tired fish from being carried downstream. These rods do not form a barrier to movements upstream because the salmon invariably leap over them.

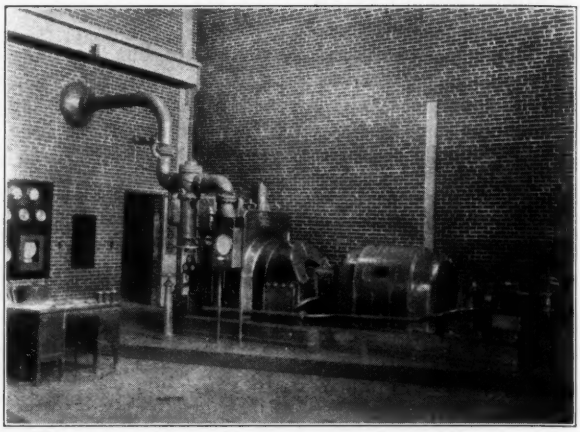
Taking advantage of the topography near the Baker River Dam, the first step in the progress of the salmon to dizzying heights is a 100-ft. fish ladder, with traps as described above, built close to the power house. Next comes about 700 ft. of flume ending in a final 2-ft. overpour at the foot of an inclined track.

And now for the elevator! It is not of the self-operated type. The pool above this last rise consists of a steel box on wheels that is hoisted up the incline when it has become full of fish. At the top of the incline, the car delivers into a hopper and the fish slide down a wooden chute into the lake back of the dam.

MATHEMATICS, according to David Hilbert, is a game played according to certain simple rules with meaningless marks on paper. Bertrand Russel, on the other hand, has defined mathematics, as "the subject in which we never know what we are talking about nor whether what we are saying is true."

THE NON-RESONATING principle which has been so successfully applied in the construction of large, high voltage transformers has recently been adapted also to auto transformers.

Small Steam Turbines for Industrial Service



IMPROVEMENT IN CONSTRUCTION AND DESIGN TOGETHER WITH INCREASED PRESSURES AND TEMPERATURES IMPROVED PERFORMANCE 5 TO 15 PER CENT DURING PAST TEN YEARS

AMONG ENGINEERS, considerable difference of opinion exists as to the probable life of turbines. This is of course influenced by the experience of the individual engineer, the industry in which this experience was obtained and the quality of operation and maintenance upon which that experience is based.

If we take the conventional 20 yr. life as reasonable we must not lose sight of the fact that although the machine may actually operate that long, if necessary, changes and improvements will likely render it obsolete before that length of time has passed.

From a mechanical standpoint there are undoubtedly thousands of 1910 turbines which could be operated.

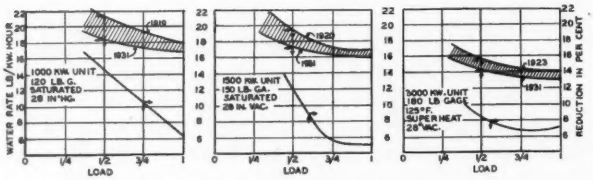


FIG. 1. IMPROVEMENTS MADE IN TURBINE EFFICIENCY DURING THE PAST 10 YR.

After considering the water rates, however, and comparing them with modern machines, operation would undoubtedly be out of the question except in emergencies.

Even during the past 10 yr. the improvement in efficiency has been sufficient to warrant a serious investigation into the economy of 1920 machines. One company reports that steam consumption on single stage machines has been reduced 5 per cent and 10 to 17 per cent since 1922 on multistage machines up to 1000 kw. Another company reports an increase in Rankine ratio efficiency of 8 per cent since 1920 on 3600 r.p.m. turbo generators of from 1000 to 10,000-kw.

One of the common engineering misconceptions is that when the turbine exhaust is utilized for process its efficiency is unimportant. This is true only in case there is an excess of electric power and live steam is sent to the process line through a reducing valve.

Increases in efficiency have been made largely by more efficient blading and designs eliminating or minimizing distortion which tends to give additional interstage clearances and leakage. Minor improvements such as governor, valve, bearing and sealing gland design have also been made. These latter improvements have been largely instrumental in improving conditions at fractional loads. Present day guarantees are based on a multiple valve system while machines of 10 or more years ago were provided with only one, two or at the most three governor valves.

Curves of Fig. 1 show the improvement in turbine water rates of 3600 r.p.m. straight condensing turbines for 1000, 1500 and 3000 kw. of still another manufacturer. These curves were drawn from ½, ¾ and full load guarantees made about 10 yr. ago under certain steam conditions and present day guarantees which would be made under the same conditions. The percentage improvement particularly in the small sizes and at fractional loads is remarkable.

It should also be noted that machines for power plants built ten years ago were designed for comparatively low steam pressures, frequently with no superheat in the steam at the turbine throttle. Modern power plants, both of the industrial type and the central station type, are very commonly built for steam pressures up to and above 400 lb. ga. and 700 deg. F. total steam temperature. In considering possible improvement in operating efficiency and cost, due to the revamping of existing industrial or central station power plants, a marked improvement in water rates can be made simply by increasing the steam pressure and temperature at the throttle, which, when taken in conjunction with the improvement in efficiency brought about by improvement in the design of the turbine, would give a much

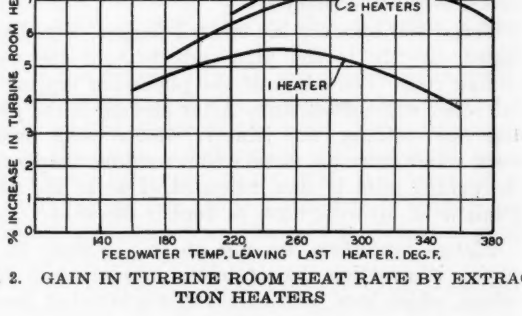


FIG. 2. GAIN IN TURBINE ROOM HEAT RATE BY EXTRACTION HEATERS

more marked improvement in overall plant efficiency than is indicated by the above figures.

Increasing the throttle pressure from 150 to 450 lb. increases the heat available for work in the turbine about 21 per cent at an expenditure of about 1 per cent additional heat in the boiler. Adding or increasing the superheat gives additional advantage as explained in detail by curves in the article Development in Power Generating Units, page 24, Power Plant Engineering, Jan. 1, 1932.

Use of extraction for feed heating also results in definite improvements in station economy as shown in Fig. 2. Bleeding for feed heating has become so common that today practically all units above 750 kw. are equipped with at least one extraction nozzle. A cross

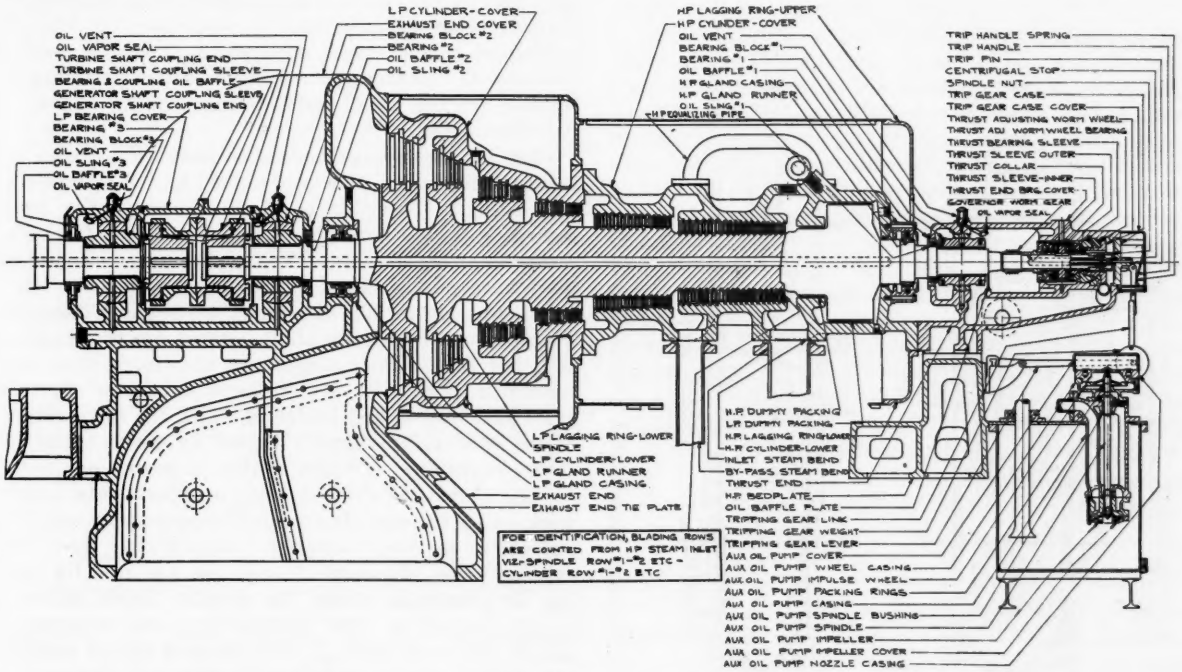


FIG. 3. CROSS SECTION THROUGH A 6000-KW. STEAM TURBINE WITH FOUR EXTRACTION NOZZLES

section of a 6000-kw. 3600-r.p.m. turbine designed with four extraction nozzles is shown in Fig. 3. Each part on this machine is identified for those not thoroughly familiar with turbine construction.

In addition to improvements from higher efficiency, higher pressure and higher temperature, there is a big field for improvement in making small changes to take advantage of newly developed or perfected equipment. This includes the use of back pressure, low pressure, extraction and mixed flow turbines. Although these machines were in use before 1920, their real development with reliable automatic control has been largely confined to the last few years.

THE EYE IS CAPABLE of adapting itself to see under illumination which ranges from a small fraction of a foot candle to several thousand foot candles. Under very low illumination, the eye does not receive sufficient light to enable it to distinguish color or detail and under unusually brilliant sunlight a blinding effect which also obliterates detail is experienced. Between these limits there is a wide range where good vision is possible.

High-Pressure Boiler Design in Europe

CASCADE-INJECTION BOILER FOR QUICK REGULATION ON PEAK LOADS. BY CHAS. J. WEBB

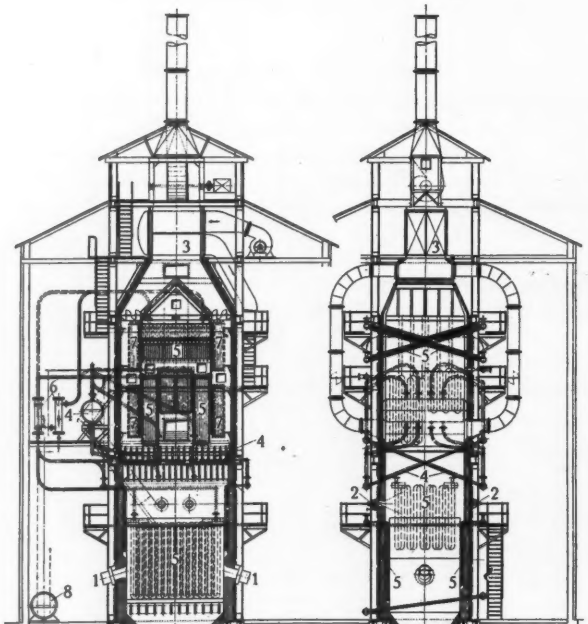
EUROPEAN high-pressure boiler developments differ from those of this country and one of the innovations is the Brown-Boveri cascade-injection type. It resembles the Loeffler boiler in that it has no heating surface in contact with the water, but only superheated surfaces. In contrast to the Loeffler boiler, however, it requires no steam circulating pump. The general principle of the new generator* is as follows: For a boiler with a working pressure of, say, 1848 lb. per sq. in., about 5 per cent of the required weight of steam is raised at a pressure of approximately 2280 lb. per sq. in., in the first so-called "exciter" stage which comprises a small boiler of any convenient design. This exciting steam is superheated in coils of tubes heated by direct radiation from the furnace and then flows to an evaporator (a small cylinder fitted with baffle pieces) situated at some convenient point outside the furnace.

In this evaporator, an excess quantity of hot feedwater, corresponding to the maximum output of the boiler, is sprayed into the superheated steam from a water reservoir lying outside the boiler but under the full steam pressure. Due to the superheat of the steam, a corresponding amount of the feedwater is evaporated, while the remainder flows back to the water reservoir. The quantity of steam, which has been increased by about 40 per cent in this first stage, now passes to a second superheater stage, then to a second evaporator stage where it again evaporates a quantity of feedwater equal to about 40 per cent of the quantity of steam flow-

*See Power Plant Engineering, p. 1217, Nov. 15, 1929.

ing into the evaporator. After at most ten of these stages, the required quantity of steam, i. e., 20 times the original quantity of excitation steam, is obtained. This is then finally superheated to the live-steam temperature required in the turbine. The steam leaves the exciter boiler at about 2280 lb. per sq. in., flows through the various superheaters and evaporators under a natural pressure drop, and passes to the turbine at 1848 lb.

The number of stages is smaller the higher the steam pressure, the greater the superheating in each stage and the higher the temperature to which the feedwater is heated. For example, steam at 425 lb. per sq. in. absolute with a temperature of 900 deg. F. in the superheaters can be produced in 10 stages, while steam at



SECTIONAL ELEVATIONS OF BROWN-BOVERI BOILER
1. Pulverized Fuel Burner. 2. Auxiliary Oil Burner. 3. Air Heater. 4. Exciter Boiler. 5. Superheaters. 6. Evaporators. 7. Economizer. 8. Water Drum

1848 lb. abs. can be raised in eight stages. The number of stages, however, has practically no influence on the design and cost of the boiler as its size is determined essentially by the heating surfaces in contact with the hot gases. In the first example, the steam is driven through the boiler with a pressure drop of about 42½ lb. per sq. in. and in the second with a difference of 28½ lb.

Steam Pump Can Be Used

In contrast to the Loeffler boiler, no pump having to circulate three to four times the working steam through the evaporators is required. The Brown-Boveri boiler can, however, be operated with an "exciter" pump instead of the exciter stage for supplying the excitation steam, this pump raising about 5 per cent of the final quantity of steam required for the initial pressure. Apart from the small exciter stage, there is in the new boiler, a complete absence of water tubes and drums with their difficulty of circulation and danger of incrustation. The steam is forced through the superheater tubes at a high velocity, thus rendering it possible to use small-diameter tubes with thin walls and therefore of light weight. In contrast to the drums of water-tube boilers, the water drum outside the boiler is not weakened by numerous holes for the tubes and is not subject to the heat of the fire; it can therefore be of light construction.

The capacity of the water drum is chosen according to the operating conditions and enables any desired flexibility to be given to the boiler. Altering the fire has a direct effect on the steam flowing through the boiler; it is unnecessary to heat up large quantities of boiler water. Since the design of the boiler avoids as much as possible all brickwork in which heat is stored, the output of the boiler can be immediately adapted to the new steam requirements by regulating the fire. It is claimed that the ease with which it can be varied renders the cascade-injection steam boiler particularly suitable for use as an instantaneous reserve and as a peak-load boiler.

The accompanying illustration shows the design of a cascade-injection boiler as designed by the Maschinenbau Anstalt Humboldt of Kalk, Cologne, who have secured a license from the Brown-Boveri Co. for their construction in Germany. The superheater coils lining the furnace all consist of exactly similar elements built up of tubes about 30—44 mm. (1⅜—1¾ in.) diameter The evaporator units in all the stages are of the same size, but in the later stages two and three units are connected in parallel. After the superheaters, the flue gases pass over a feed heater in which the temperature of the condensate (usually heated by steam extracted from the turbine) is raised to that of saturation.

The Humboldt Co. has had an experimental boiler working on the cascade evaporation system in continuous use in its own works for a considerable time. An existing boiler of somewhat large size was used for raising the excitation steam, the quantity being approximately doubled in three superheating and evaporating stages. The test, which it was intended should provide information regarding the superheaters and evaporators, is stated to have proved the parts, and indeed the whole system, to be entirely suitable.

An extensive test to determine the efficiency value of violet ray lamps on office workers is being conducted in the Pittsburgh office of the Philadelphia Co. Fifty girls in the utility company's billing department are subjects of the experiment, comments the New Jersey Public Utility Information Committee. The experiment, in addition to producing a bevy of bronze-complexioned maids for the winter season, is expected to demonstrate whether or not the rays will improve the health of the girls and their efficiency. In another department fifty more girls are working under the same conditions as the others, but without the rays. At the end of the test period, the efficiency of the two groups will be compared.

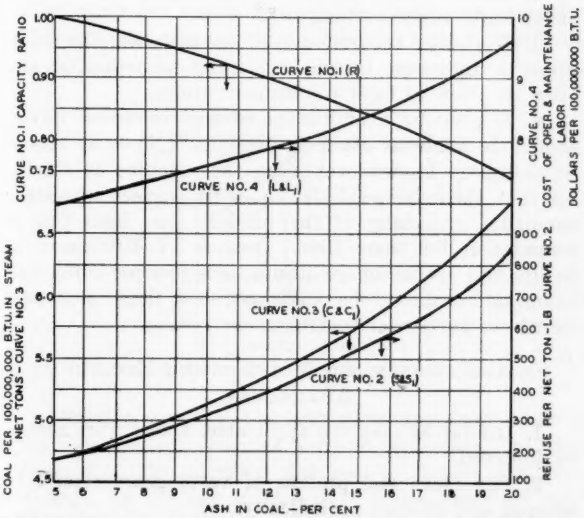
Soldering paste or stick can be made as follows: Melt 1 lb. of tallow and add 1 lb. of common olive oil; stir in 8 oz. of powdered rosin; let this boil up and when partially cool, add, stirring constantly, ¼ pint of water that has been saturated with powdered sal ammoniac. Stir constantly until cool. By adding more rosin to make it harder, it can be made into sticks.

Value of Clean Coal for Steam Generation

FORMULAS FOR CALCULATING THE EFFECT OF ASH CONTENT ON STEAM COSTS. BY EDWIN B. RICKETTS*

COAL has many characteristics the variations in which materially affect its value for use on most types of combustion equipment. The scope of this paper is, however, confined to the effect of variations in the ash content of coal on its value for steam generation.

Development of the art today offers combustion equipment capable of providing the necessary capacity, together with good efficiency, when supplied with almost anything in the way of fuel from the best grades of coal having an ash content of 4 to 5 per cent to a black


CURVE NO.1 CAPACITY RATIO
CURVE NO.4 COST OF OPER. & MAINTENANCE LABOR DOLLARS PER 100,000,000 B.T.U.
COAL PER 100,000,000 B.T.U. IN STEAM NET TONS - CURVE NO. 3
REFUSE PER NET TON - LB CURVE NO.2
CURVE NO.1 (R)
CURVE NO. 4 (L&L1)
CURVE NO.3 (C&C1)
CURVE NO. 2 (S&S1)
ASH IN COAL - PER CENT

RELATION OF COST FACTORS TO ASH PERCENTAGE OF COAL

real estate containing 40 to 50 per cent ash. Thus, if the type of fuel to be used is definitely known in advance of design suitable equipment can be provided, at a cost, for its combustion. Development of the art of cleaning coal has reached a point where, by the use of suitable methods, there can be manufactured, at a cost, from high ash coals a product suitable for use on combustion equipment designed for high grade fuel.

If our problem were the simultaneous development of a steam plant and a low grade coal field to supply that steam plant, both properties being under common ownership, we would have a simple case of balancing the cost of coal cleaning against that of burning the high ash coal, but such a situation is very much the exception.

The cheapest coal to use in any given plant is that coal which, considering fixed and operating charges, will produce the most heat units in the steam for a dollar. Factors in the cost of steam production that are influenced by the ash content of coal are: Capacity available; cost of coal per million B.t.u. in bunkers; boiler plant efficiency; cost of operating labor and maintenance per million B.t.u. in steam; cost of ash handling and disposal per million B.t.u. in steam.

While the fundamental formulas involved in a determination of the effect of variations in ash content on the cost of steam generation are of universal application, the constants involved vary through quite wide limits due to differences in fuel burning equipment and in the cost of labor and materials.

Below are given the formulas for calculating the effect of variations in ash content on the cost of steam generation, together with a number of examples of their practical application. While the constants used in these examples are the average of those experimentally determined for three large boiler plants, they should be considered as illustrative only and before the solution of a specific problem is undertaken the value of the constants applicable to the plants under consideration must be determined.

Assumptions: Maximum steam demand is equivalent to 100,000,000 B.t.u. in steam per hour on a plant with a capacity of 100,000,000 B.t.u. in steam per hour when supplied with 5 per cent ash coal. Cost of the boiler plant complete is $300,000.00. Additional capacity can be purchased for $3.00 per 1000 B.t.u. per hour in steam. Fixed charges at 12.5 per cent per year or $4.28 per hour.

Let X = Cost in dollars per net ton of 5 per cent ash coal in bunkers
Y = Value in dollars per net ton of x per cent ash coal in bunkers
Z = Total cost of 100,000,000 B.t.u. in steam with 5 per cent ash coal
Also Z = Total cost of 100,000,000 B.t.u. in steam with x per cent ash coal if this coal costs Y dollars per ton
C = Net tons of 5 per cent ash coal required to produce 100,000,000 B.t.u. in steam
C_1 = Net tons of x per cent ash coal required to produce 100,000,000 B.t.u in steam
S = Pounds of refuse per net ton from 5 per cent ash coal
S_1 = Pounds of refuse per net ton from x per cent ash coal
U = Cost of ash handling and removal in dollars per pound
L = Cost in dollars of labor and maintenance to produce 100,000,000 B.t.u. in steam with 5 per cent ash coal
L_1 = Cost in dollars of labor and maintenance to produce 100,000,000 B.t.u. in steam with x per cent ash coal
A = Capacity factor
$$= \frac{\text{B.t.u. absorbed by steam per yr.}}{\text{Max. cap. B.t.u. absorbed per hr.} \times 8760}$$
B = Fixed charges per hour on cost of boiler plant. Assumed = $4.28
R = Capacity ratio
$$= \frac{\text{Max. cap. of boiler plant with x per cent ash coal}}{\text{Max. cap. of boiler plant with coal used as a base}}$$

Formulas:
Value relative to 5 per cent ash coal as a base

1. Where excess boiler capacity is available and investment factors need not be considered

$$Z = CX + CSU + L = C_1Y + C_1S_1U + L_1$$
$$C_1Y = CX + CSU + L - C_1S_1U - L_1$$
$$(1) \qquad Y = \frac{CX + CSU + L - C_1S_1U - L_1}{C_1}$$

2. Where excess boiler capacity is not available and investment factors must be considered

$$Z = CX + CSU + L + \frac{B}{A} = C_1Y + C_1S_1U + L_1 + \frac{B}{AR}$$
$$C_1Y = CX + CSU + L + \frac{B}{A} - C_1S_1U - L_1 - \frac{B}{AR}$$
$$Y = \frac{CX + CSU + L + \frac{B}{A} - C_1S_1U - L_1 - \frac{B}{AR}}{C_1}$$

*Research Engineer, New York Edison Co., New York, N. Y. From a paper presented at the Third International Conference on Bituminous Coal, Carnegie Institute of Technology, Pittsburgh, Pa.

(2)

Example 1. Investment factors not included

When 5 per cent ash coal costs $4.00 per net ton in bunkers and ash handling and removal costs $0.20 per ton, find the value of 18 per cent ash coal. We have:

C=4.67 (from curve No. 3) C_1=6.28 (from curve No. 3)
X=$4.00 S_1=695 (from curve No. 2)
S=160 (from curve No. 2) L_1=$9.00 (from curve No. 4)
U=$0.0001
L=$7.00 (from curve No. 4)

Substituting in equation (1)

$$Y = (4.67 \times 4. + 4.67 \times 160 \times 0.0001 + 7 - 6.28 \times 695 \times 0.0001 - 9) \div 6.28 = \$2.60$$

Example 2. Investment factors included

When 5 per cent ash coal costs $4.00 per net ton in the bunkers, ash handling and removal costs $0.20 per ton, capacity factor is 0.50. Find the value of 18 per cent ash coal. We have:

C=4.67 (from curve No. 3) C_1=6.28 (from curve No. 3)
X=$4.00 S_1=695 (from curve No. 2)
S=160 (from curve No. 2) L_1=$9.00 (from curve No. 4)
U=$0.0001 A=0.5
L=$7.00 (from curve No. 4) B=$4.28
A=0.5 R=0.78 (from curve No. 1)

Substituting in equation (2)

$$Y = (4.67 \times 4 + 4.67 \times 160 \times 0.0001 + 7 + \frac{4.28}{0.5} - 6.28 \times 695 \times 0.0001 - 9 - \frac{4.28}{0.5 \times 0.78}) \div 6.28 = \$2.22$$

It will be noted from Example 2 that, for the particular plant under consideration, an increase of 13 per cent in ash reduces the value of the high ash coal by nearly 50 per cent. Obviously, under ordinary circumstances this low grade coal can not be supplied to this type of plant at a mutually profitable price.

A coal operator confronted with such a situation will, having in mind the cost of cleaning his product, consider the relative advantages of manufacturing from his raw material a more suitable product, or seeking a market where the combustion equipment is better suited to his coal.

The problem of the mutual adaptation of coal and combustion equipment has been faced many thousands of times; in some cases it has been solved by the better cleaning of the coal, in others by changes in the combustion equipment or, in both coal cleaning and combustion equipment. In a relatively small number of cases, the decision has been based on an exhaustive analysis of the engineering and economic factors involved, but in the vast majority the foundation for the decision has been little more than a hunch.

This paper is offered in the hope that the solution of the example presented will emphasize the necessity for the mutual interest of coal producer and consumer in the scientific determination of the factors governing the economics of both the cleaning and the combustion of coal to the end that some combination of cleaning and combustion equipment be selected which will produce the greatest amount of steam for a dollar.

Operating Code Manual for Power Plants

Routine, Care and Maintenance of Turbines and Auxiliaries Necessary for Reliable Operation

SATISFACTORY and safe operation of power plant equipment depends upon the design of the equipment and care it receives. Practically all equipment available today has been proven in service and if properly operated will give good service. Detailed directions for all types of equipment are impossible but the following outline indicates the points that should be watched:

Turbines, General

1. Machines should always be kept as clean as possible and wiped periodically.

2. Inspect wheel and thrust clearances periodically and make necessary adjustments.

3. Make complete internal inspection of turbines periodically and make necessary repairs.

Turbines Oiling System

1. Oil should be carefully watched, maintained in good condition and changed when necessary.

2. Clean the screens of the turbines oiling system periodically as required by local conditions.

3. Blow out the cooling coils of the oil cooling system when necessary, as shown by the oil and water temperatures.

4. Clean the oiling systems and gravity filter tanks when necessary.

Turbine Governors

1. Examine the worms and gears of the governors periodically and repair them, if necessary.

2. Inspect the needle valve oil supply to the governor knife edges periodically.

3. The roller transmission of the governor should be given a thorough internal cleaning periodically and oiled as often as local conditions require.

4. A periodic examination of the overspeed device should be made as often as possible. (Note: It should be definitely known each time the machine is started up that the overspeed device is in perfect operating condition, especially if the machine has been out of commission for some time. Because of differences in design and operating conditions, it is recommended that examination should be made not less than once each month on horizontal turbines.)

Small Turbines and Reciprocating Engines on Auxiliaries

1. Insofar as they are applicable, above rules should be followed.

2. The racks and pinions of valve gears should be scraped and cleaned periodically.

Condensers

1. Examine the interior of condensers periodically.

2. Clean condenser tubes when necessary.

Miscellaneous

1. Examine motor operated valves periodically and make necessary adjustments and repairs.

2. All remote control valves should be operated periodically.

3. All water strainers should be kept clean.

4. Operate the main valves of the forebays periodically, being sure adjacent valves are open as each is manipulated.

5. Clean out the debris from the bottom of the screen basin well and overhaul the apparatus periodically.

WHEN THREE TRANSFORMERS are connected to a three phase circuit with the primaries in delta, the wave form of current required by each transformer is the same as when one transformer is connected to a single phase circuit. If the three transformers are identical and the line voltages balanced, the line currents will be distorted but will not contain any third harmonic components.

Power Utilization

Single-Phase Motor Trouble

By Grady H. Emerson

TO DRIVE an air compressor at a large oil company's shops, a 5-hp., single-phase, repulsion-start, induction-run motor was operated by an automatic controller. After satisfactory operation for several years in one plant, it had been moved to another.

When wired up at the new place, sometimes it would cut in and operate perfectly; at other times it came up to right speed but the short-circuiting device would not function. This would, of course, cause the motor to draw abnormal current and to heat, so that, if operated for any length of time with anything near full load, the motor would probably have burned out.

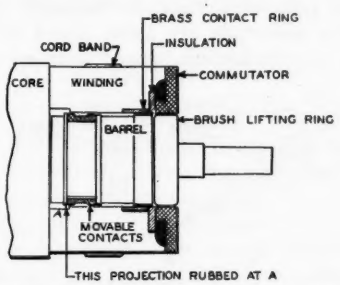


DIAGRAM OF MOTOR CONNECTION CONTROL

Fused properly, it would blow the fuse when it reached overload current but, in this case, the first thing that the operator did was to double the fuse, 30-amp., by putting in two links which made 60 amp. This was all right for starting purposes but, as the code only allows 35 amp. for running protection and at full load the motor draws only 27 amp. at 220 v. the chances are that the winding could have been seriously damaged before the fuse would act.

Everything which might affect the motor was checked, all joints inspected and voltage tested. The brushes were set with the motor running and found to be set correctly. As on several trials the centrifugal device failed to operate, the parts shown in the accompanying sketch were removed and examined.

The barrel was found to fit snug upon the shaft, so the shaft was polished with fine emery paper and the motor reassembled. We got the same results as before. With movable contacts taken off, the barrel, when pushed in and out by hand was found to hang almost every time but the friction was insufficient to make a noticeable mark. The inner circle of the barrel was chamfered with a file at the inner end and it was again reassembled. Again the motor would not operate properly every time.

Removing the end frame, all moving parts were marked with ordinary bluing and the motor reassembled. When it failed to come up to speed, it was taken apart and we found that the blue had been scraped off the projection used for holding the movable contacts. It had been deposited at A. The barrel was chucked in a lathe and a cut of 1/32 in., just sufficient to true up this shoulder was taken. When reassembled this time, the motor was found to operate successfully after every trial.

Sketch shows the cross section, although actuating spring and holding nut are not shown. The barrel is forced outward along the shaft by pins which are actuated by weights located on the rear of the armature. When it is forced to the limit, the brushes are lifted from the commutator and the movable contacts at the inner end of the barrel short circuit the brass ring and the commutator segments, which gives induction motor operation.

Hard Sheaves Wear Less

HARD ROPE may wear or even cut a sheave of soft material; then the worn sheave subjects the rope to abnormal wear, both external and internal. Of itself, wearing of sheaves is not a serious matter except as the deepened grooves afford too little clearance for the rope; they fit it too well. The radius of the bottom of the groove is slightly too small and sides are quite too steep.

In use, a slight amount of flattening of rope is inevitable from bending and pressure as the rope wraps around the sheave. Unless there is room between the sides of the groove for this normal flattening to occur, the rope is pinched, which will cause surface wear as the rope enters and leaves the groove.

As the rope assumes the curvature of the sheave, the strands must slip slightly among themselves, also the wires within the strands, causing internal wear. If the rope is pinched in the groove, the strands bind against one another, thus increasing abrasive friction and hindering movement so that strands at the top of the groove are forced to carry more than their share of the load.

Soft sheaves may wear in corrugations to fit the lay of the cable. Wire rope is not designed to work as silent chain, nor a sheave as a sprocket. These corrugations have their part in hindering inter-strand movement; also, as the sheave wears smaller, the pitch of its corrugations becomes shorter, while the length of lay of the rope, if it changes at all becomes longer, the points of the bearing are shifted and the rate of wear accelerated.

Standard rope has a tendency, under certain conditions of operation, to unlay slightly under tension, the twist accumulating toward one end of the rope. When tension is released, the rope regains its normal lay and, in so doing, may turn more or less in the groove of a sheave over which it passes, causing sheave wear.

Effects are bad enough on rope which does the wearing; but, if a new rope, unworn, hence larger than the old be put to work on worn sheaves, the new rope may fail in a few hours. If not and it enlarges the groove, much of the useful life of the rope has been sacrificed.

By resisting wear, hard sheaves preserve a proper groove profile longer and give the rope a chance to work under favorable conditions. Sheaves and preferably drums also should be at least as hard as the steel in the wires of the rope. For severe service, manganese steel has proved itself economical in the long run. In any case, when installing a new wire rope it should be calipered accurately as to maximum diameter and the size and shape of the grooves gauged to make sure that clearance is the amount specified by the cable maker for that size and construction of rope. This may call for widening and truing up of the deepened part of the groove, which is an expense but is real economy.

Preforming of rope is designed to reduce internal wear and pressure among the strands. If such a rope be pinched in a groove, precisely at the point where interstrand movement must occur, the external pressure causes chafing between the strands, nullifies the advantage of the special construction and to that extent deprives the user of the expected longer life. When preformed rope is installed to replace twisted rope, fitting the grooves to the rope is especially important.

Pipe Identification by Color Code

WHILE the importance of marking piping and valves, especially those carrying and controlling dangerous material has often been discussed, observation shows that in many plants, systematic marking has not yet been carried out. Color schemes, more or less arbitrary, have been used in industrial plants for many years but a standardized plan, developed by a representative committee of industrial engineers is now available and may well be followed.

FIG. 1. THE COLOR CIRCLE DIVIDED INTO FIVE PARTS REPRESENTING THE FIVE MAJOR DIVISIONS OF THE COLOR CODE

In this plan, fluids are divided into five classes as shown in Fig. 1, with colors readily distinguishable and having already established association.

In addition, letter symbols are used as indicated in the accompanying table.

Red and fire departments have long been associated. Yellow and orange for danger are most readily distinguished of all colors and are used as a danger sign for quarantine and traffic signals. Green is universally known as the safety color. Where desired, shades of these colors may be used for subdivisions of materials of various kinds.

CLASSIFICATION OF FLUIDS WITH COLORS AND SYMBOLS FOR IDENTIFICATION

Class	Color	Letter Symbol
Fire protection equipment	Red	F
Dangerous materials	Yellow	D
	Orange	
Safe materials	Green	S
	White	
	Black	
	Gray	
	Aluminum	
Protective materials	Bright Blue	P
Extra valuable materials	Deep Purple	V

CLASSES OF FLUIDS

Safe materials are in the majority, involve no hazard in handling, are not of extraordinary value and breaking into a line by workmen involves no serious hazard, even though the line be not drained.

Dangerous materials are hazardous to life and property because poisonous, easily inflammable or explosive.

Protective materials are those piped especially for overcoming or minimizing hazard such as antidotes to poisons or burns, generally to be released in case of danger.

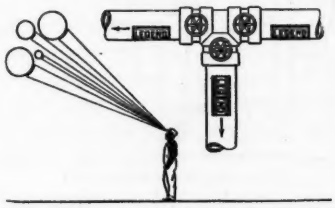


FIG. 2. WHEN LEGENDS ARE USED, THEY SHOULD BE CAREFULLY LOCATED

SIGNS AND SYMBOLS

Instead of color shades for special materials it is sometimes of advantage to use a lettered name of the material carried and arrows to show the direction of flow as indicated in Fig. 2. Here visibility is important and signs should be so arranged, especially where pipe lines are grouped, that unobstructed view is obtained from some convenient point with good lighting. Lettering below the horizontal diameter of the pipe is less subject to obscuring by dust or mechanical damage. All legends should be clean and of size to be easily read from considerable distance. For pipe under ¾ in., metal tags painted or enameled may well be attached to the pipe. For larger sizes, lettering sizes may be as follows:

Outside Diam. of lettered surface, In.	¾-1¼	1½-2	2½-3	3½-4	4½-5	6-7	8-10	12
Height of letter, In.	½	¾	⅞	1¼	1½	1¾	3	3½

Care should be taken that the paints used will not deteriorate or change color under the exposure to which they are subjected. For outdoor use, linseed oil is most durable but, if extra resistance to water is required, china-wood-oil varnishes may be used.

Darker shades in browns, red and purples are less easily distinguished than bright shades; also greenish blues and olive green are easily confused.

Examples of various common fluids and their classification and of color combinations to indicate special materials, are as follows:

Material	Classification	Color-Stripes	Usual Temp. Deg. F.	Usual Press. Lb. Sq. In.
Brine	Safe–S	Green	0-20	60
Comp. Air	Safe–S	Gray	80	50-300
CO_2	Dang.–D	Orange	30-100	0-250
Ammonia	Dang.–D	Yellow-Purple	30-100	0-250
Gas	Dang.–D	Orange-Black	0-200	½ in. 250
Foamite	Fire–F	Red-Blue	0-60	100
Oils	Dang.–D	Orange-Purple	50-500	20-1200
Soda Ash	Safe–S	White-Blue	0-100	60
Steam				
Saturated	Dang.–D	White-Orange	100 & up	100 & up
Superheated	Dang.–D	Gray-Orange	300 & up	250 & up
Steam				
Saturated	Dang.–D	Yellow-White	200 & up	20-100
Saturated	Dang.–D	Yellow-Green	100 & up	0-20
Vacuum	D	Yellow-Gray	50-150	
Water				
Fire lines	Fire–F	Red		
Fresh	Safe–S	Green		
Circulating	Safe–S	Green-Blue		
Boiler Feed	Dang.–D	Green-Orange	100-200	100-400
Condensate	Safe–S	Green-Black	50-100	5-50
High Press	Dang.–D	Green-Yellow		50-1000

Plans for Electrical Distribution Systems

POINTS TO BE considered in making plans are the relative importance of maximum economy, maximum reliability, voltage regulation, power factor correction and flexibility of switching control. Certain of these will be likely to conflict and several single-line sketch diagrams should be drawn and their advantages considered to determine in what way compromises may best be effected.

Analysis of the problem requires consideration of present and future building plans and manufacturing requirements, physical layout, variation and probable growth of electrical load, lighting necessities. These must be provided for in each of the sketch plans and tabulation made of costs, efficiencies, space needed and reliability, reducing each to a dollar value for determination of best ultimate economy.

Modern practice tends to use alternating current with special direct-current requirements such as welding or electrolytic work supplied from motor-generator sets placed near the center of consumption, the direct current load being concentrated as much as possible. If, however, most of the load is direct-current, direct-current main generators may be advisable, a.c. motors, if essential being fed by motor-generator sets. In either case, for polyphase or 3-wire systems, heating and lighting equipment should be so connected as to give balanced load.

Lighting System

Because of location, need for close voltage control and greater permanence of arrangement, lighting circuits are usually separated from power lines. Lamps are made for 105 to 130 v., available in 5-v. steps, and voltage should be chosen to fit in with power requirements to give maximum light per dollar of cost. For instance, with lamps costing 0.4 cent per watt rating and power at 1.5 c. per kw-hr., Mazda lamps rated for 115 v. used on a 110-v., circuit will give 86 per cent lumen output, using 93 per cent of rated watts or 92 per cent rated lumens per watt with 180 per cent of rated life, a maximum amount of light per dollar.

For outside lighting, the series system with constant current of 6.6 amp. furnished by standardized constant-voltage to constant-current transformers permits lamps up to 6000 lumens or, with 20-amp. current, lamps to 25,000 lumens. Multiple lamps for constant voltage are usually cheaper also the wiring and controls are less expensive, simpler, more efficient and permit more flexible arrangement.

Inside lighting is almost universally by constant voltage lamps of size and with fixtures to give well diffused light, free from shadows.

Power Feeders

Daily load curve should be drawn for each department and the feeders for that department planned accordingly. From the combined curves, the total system load can be estimated and main feeders and transformers provided, allowing for probable future growth. The number and duplication of feeders and provision for current supply by more than one path will depend on the importance of freedom from service interruptions, relative to costs of the different proposed systems. Generally it is wise to have alternative methods of supplying power to each important department, either by cross overs from feeders that can temporarily carry an overload or by duplicate feeders well-separated or traversing separate routes.

Power Factor Correction

Current for magnetizing transformer, motor and magnet cores lags behind impressed electromotive force, especially when oversize equipment is operated at low load. Power factor correction is desirable to permit smaller capacity of generators, transmission line and transforming equipment. Also efficiency and voltage regulation are improved.

Power factor can be improved by so grouping load on motors and transformers that they will operate most of the time at nearly full rated load.

Oversize synchronous motors, operated overexcited, or static condensers (capacitors) should be installed as near as possible to the center of the system whose power factor is to be corrected. Synchronous motors should be used on drives having high load factor such as air compressors, blowers or refrigerating machinery. In emergency, the synchronous motor may be run without load, as a synchronous condenser.

Where capacitors are used, they are better applied at the centers of power distribution rather than to individual motors as this gives better correction at lower cost of installation.

If power is purchased, lowest rates usually depend on maintaining power factor above a stated minimum value, hence considerable expense in power factor correction is justified by the decrease secured in power bills. When power is generated, justifiable expense may be less but correction to hold power factor up to 0.8 is usually good economy.

Primary Distribution

Voltage to be used will depend on the transmission distance from source to load, size of load and comparative cost of copper in the feeders as against cost

of insulation and installation. Higher voltage reduces transmission loss but increases installation cost. If generator voltage can be used for transmission and utilization, cost of transforming equipment can be saved.

The system may be laid out with radial feeders or as a loop or network, the last two giving greater dependability but usually at higher first cost, where the system is spread out over considerable area. Three-phase, three-wire arrangement is common for industrial plants, with 440 and 220 v. lines for motors and 110 v. for lighting.

Unbalanced Motor Currents

By Edward W. Johnston

WHERE 3-PHASE line voltages are balanced but phase currents are not, the trouble is in one coil whose resistance is different from that of the other two coils. This coil may be partially short circuited or some of the soldered joints may be perfect while others are defective. This is the case in the problem on p. 183, of Feb. 15 issue.

Assuming that the motor is either Y or Delta connected without neutral, which is always the case in practice, no uniphase currents of impressed frequency can possibly flow. The unbalanced current vectors, therefore form a closed triangle and may be decomposed into two balanced systems of positive and negative phase sequences respectively.

It is well known that, when the currents in a polyphase induction motor are balanced, a revolving field is set up in the air gap. This field, which in the ideal case is sinusoidal distribution, revolves with synchronous speed with respect to the stator windings. It induces currents in the rotor windings and torque is produced in the direction of the revolving field. The slip of the motor will automatically adjust itself until the internal torque, which is proportional to the product of the stator and rotor currents is equal to the sum of the total load torque and the torque due to the losses, hence is sufficient to keep the motor operating. If the motor is incapable of producing an internal torque of the necessary magnitude, it will stall and the rotor will come to rest.

When the motor draws unbalanced currents, equivalent to the two balanced current systems of opposite phase sequence, its performance may be determined by considering the effect of each system separately and superimposing the results. Each of the balanced current systems may be looked upon as giving rise to a revolving field in the air gap. Obviously, these fields, viz., the positive and the negative sequence fields, will rotate in opposite directions, hence in conjunction with the currents that they induce in the rotor windings will produce oppositely-acting torques. The positive sequence torque acts in the direction of the rotation of the rotor. This torque, therefore, must equal the sum of the negative sequence torque and the torque due to the load and the losses.

If the rotor turns over at synchronous speed, the positive sequence slip, which is the actual slip of the motor, is zero, while the negative sequence slip has its maximum value, namely 200 per cent. If the slip (positive sequence) is s, the negative sequence slip is $200—s$.

With unbalanced currents, the copper losses, hence the amount of heat developed in the three phases of the stator will be unequal. One phase (and frequently two, depending on the amount of unbalance) will be heated considerably more than when the motor delivers the same output on balanced currents.

Copper losses in the rotor phases, although higher than for balanced operation will be identical, even when the motor operates on unbalanced currents. This is due to the fact that each rotor phase carries the same effective values of the two currents of different frequency, in magnitude equal to the positive and negative sequence load components in the stator windings. The core loss will usually increase somewhat when the motor is operated on unbalanced currents.

Power Loss from Removal of Core Water

Investigation Shows that Removal of 20 Per Cent of Water By Core Sucker Increases the Power Consumption About 1 Kw-hr. Per T. and Increases the Production Costs About 0.5 Per Cent

QUALITY OF RAW WATER ice can be improved by proper air agitation and by the removal of the concentrated water in the core of the partially frozen can. In one experimental investigation,* it was proposed to remove and completely reject approximately 20 per cent of the water originally subjected to cooling. Such practice in the past has been viewed with considerable disfavor by the practical operator who holds that large core removal incurs too great a power loss. For this reason it was advisable to determine what percentage of power required in the production of a ton of ice from water at 70 deg. F. would be required to cool the additional 400 lb. of water used when a 20 per cent core is removed. It was assumed that the core water was removed at 32 deg. F. and entirely wasted, no attempt being made to effect any degree of heat exchange.

Without core removal, assuming a 100-t. plant, with a brine temperature of 16 deg. F., and considering all factors such as miscellaneous losses, heat loss through insulation, heat removed from air for agitation and heat from the brine agitator, it was calculated that 219.73 B.t.u. would be absorbed by brine for each pound of ice produced. This is equivalent to 439,460 B.t.u. per ton of ice. Then assuming liquid ammonia in the coils must be held at a temperature of 10.55 deg. F. (corresponding to a suction pressure of 24.3 lb. per sq. in.) to maintain a brine temperature of 16 deg. F. and with a water temperature of 75 deg. F., that temperature of the liquid ammonia could be held to 85 deg. (condenser pressure of 151.7 lb. gage) a calculated theoretical power consumption 20.35 kw-hr. per t. of ice produced would be necessary. Actual power consumption for these conditions was determined as 30.89 kw-hr. per t., giving an indicated efficiency of the actual machine of 65.91 per cent.

*See Treatment of Water For Ice Manufacture. Bulletin 219, Engineering Experiment Station, University of Illinois.

20 Per Cent Core Removal Increases Power Consumption 3.56 Per Cent

With the core removal of 20 per cent, for 400 lb. water per ton of ice, the additional heat removal to cool the water from 70 to 32 deg. F. would be 15,200 B.t.u. which, assuming this same efficiency of 65.91, would increase the power consumption to 31.99 kw-hr. per t. The added power required for the 20 per cent core removal is therefore 1.1 kw-hr., representing an increase of about 3.56 per cent.

In actual practice, the water used to replace the core solution is cooled from 70 to 32 deg. F. largely by the melting of ice previously formed. In a 400 lb. ice can the removal of a 10-gal. core leaves a core cavity having the approximate dimensions of 4 x 15.5 x 55 in. with an exposed ice area of 2145 sq. in. To cool the 10 gal. of water requires the melting of 22 lb. of ice representing a layer 0.3 in. thick, which should theoretically increase the total freezing time. Although plant observations have not indicated that any marked increase does occur, the difficulty, if actually present, may readily be overcome by externally precooling the core water to approximately 32 deg. F. before its addition to the core cavity. With an average cost of production of $3.12 per t., of which the total power cost is $0.825, the increase in power of 1.1 kw-hr. per t. occasioned by the removal of the 20 per cent core would result, at $0.015 per kw-hr., in an increased total production cost of 1.1 x $0.015 or $0.016 per t., an increase of about 0.5 per cent.

Increase in total cost thus occasioned is seen to be of secondary importance so that no hesitancy should exist in adopting this measure to prevent the occurrence of opaque ice whenever possible. It is obvious that the increased power resulting from core water removal will be materially reduced if the cold solution is utilized in suitable heat exchanger before being wasted. In a plant producing 100 t. of ice a day, the removal of a 20 per cent core results in 5000 gal. of water for this purpose.

Air Conditioning to Meet Special Requirements

Centrifugal Cold Air Machine and Expansion Motor Meets Difficult Conditions in South African Mine

IN THE PAST, air has been used as a refrigerating medium but because of necessary large volumes and low pressures, the dense air ice machine has completely disappeared. Recently, however, a new type air machine has been applied to air conditioning. It is interesting because a centrifugal compressor using air as a cooling medium is used under unusual conditions which undoubtedly are paralleled in many industrial processes.

In the conventional compressor system using ammonia, carbon dioxide or other fluid as a refrigerant, the equipment is arranged somewhat as shown at the left of Fig. 1. If direct expansion coils are not allowed, an intermediate stage in which water cooled in the expansion coils is in turn used to cool the air either in direct contact coils or by a spray, may be added. In the cold air machine to be described, air is the only refrigerant used, being compressed, cooled and expanded for the purpose of getting the desired terminal conditions of temperature and humidity as shown diagrammatically at the right of Fig. 1.

In this particular installation made by Brown-Boveri for the Anglo-American Corp. mines in South Africa, conditions were unusual. Machines employing usual refrigerants could not be used in the mine nor could air ducts or brine lines be run from the surface because of the long distance and depth of the shaft. Saturated air as a pressure of 14 lb. abs. 95 deg. F. was to be cooled to a minimum of 32 deg. F.; available cooling water was 80 deg. F.; motor drive to be used but the heat from motor losses was not to be allowed to escape in the mine; dimensions of any single piece limited to about 4 by 5½ ft. cross section by 10 ft. long with a total machine height of about 8 ft.

The machine built for this service is shown by Fig. 2 and is arranged somewhat as shown diagrammatically in Fig. 1, except that the intake air is drawn through the motor so as to absorb the heat losses. With the

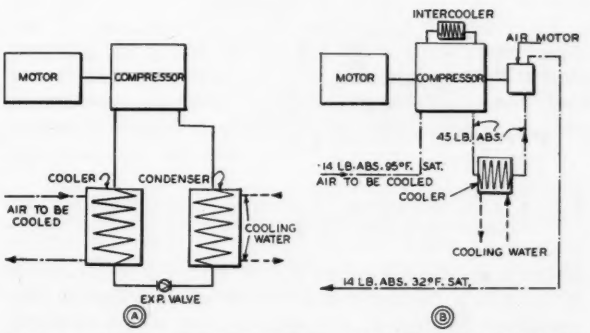


FIG. 1. (LEFT) CONVENTIONAL COMPRESSOR COOLING SYSTEM. (RIGHT) COLD AIR MACHINE

high temperature of cooling water, precooling was not considered economical.

Equipment and Power Requirements

In Fig. 2, the 2000-v., 50-cycle, 2980-r.p.m. motor, 1, drives the four stage centrifugal compressor, 3, at 13,900 r.p.m. through the single gear 2, with a power consumption of 236 kw. The compressed air is cooled by an intercooler, 4, and a cooler 5, and condensed moisture separated by the condenser or collectors 8. The compressed air at a pressure of three atmospheres, cooled close to the 80 deg. F. cooling water temperature, is then expanded in the air motor, 6, mounted on the end of the shaft. After expansion, the air temperature is about 32 deg. F. and the air is passed through the separator, 7, on its way to the ventilating duct.

In expanding through the air motor, some of the work of compression is returned as useful work, the balance required for driving the compressor is furnished by the motor. Air enters the machine through ports in the base of the motor as indicated by the arrows. Capacity is 3000 c.f.m. of 14 lb. abs. 95 deg. F. saturated

air. This is heated to 120 deg. F. by the motor, compressed to 43 lb. absolute, cooled and expanded as described above.

In operation, it has been found that the separated moisture absorbs some of the CO_2; the mine dust that causes silicosis is removed and the high compressor temperature has a germicidal effect. The ventilating arrangement is in the form of a local closed circuit with hot air drawn from one portion of the working space and the cooled air supplied to another. Under other conditions it would probably be desirable to mix or temper the output of the machine with a larger stream of ventilating air in order to avoid undesirable local cold spots and drafts.

In designing the unit, the power required for driving the compressor was estimated at 280 kw. of which 80 kw. would be recovered from expansion in the air motor, leaving a net of 200 kw. to be supplied by the motor.

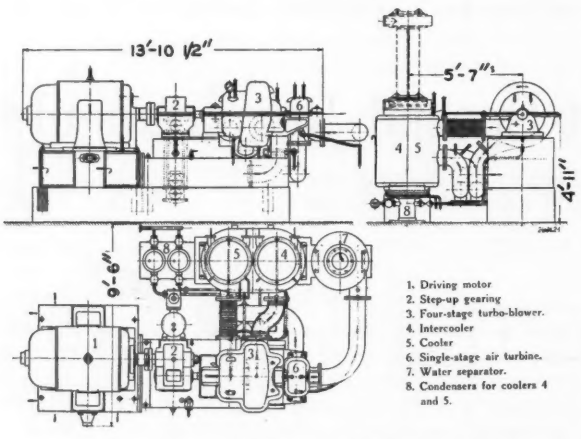


FIG. 2. ARRANGEMENT OF MOTORS, COMPRESSOR AND COOLERS FOR AIR DRYING AND COOLING PLANT

Motor heat losses absorbed by the air were calculated as 17 kw. In a factory test in which air was heated electrically to 95 deg. F. and saturated by means of steam jets, the following data were obtained:

Power consumption, kw	236
Pressure, lb. per sq. in. abs	14
Volume of 95 deg. F. saturated air, c.f.m.	3000
Volume of 95 deg. F. dry air, c.f.m	2824
Weight of 95 deg. F. dry air, lb. per min.	192
Weight of moisture at inlet, lb. per min.	7.51
Weight of water removed, lb. per min	6.07
Wt. of moist. 32 deg. F. sat. air, lb. per min.	0.71
Theoretical extraction per cent	90.5
Wt. of act. moist. in disch. air, lb. per min.	1.44
Actual extraction, per cent	81.9
Volume of 32 deg. F. dry air	2520.

Practically all the water was collected from the intercooler, although a second design of separator proved to be more efficient than the first and it is probable that the final moisture content was later reduced.

Refrigerating Effect

Moisture in the air is literally squeezed out because the moisture carrying capacity of air at 14 lb. absolute 95 deg. F. is much greater than at 43 lb. absolute 95 deg. F. Taking the specific heat of dry air as 0.2375, the total heat of saturated vapor at 95 deg. F. as 1102. B.t.u. per lb.; the heat of water at 95 deg. F. is 63 B.t.u. per lb.; the heat of saturated vapor at 32 deg. F. as 1073.4 and the heat of water at 32 deg. F. as 0 it is possible to approximate the refrigeration effect.

Taking this equal to the heat loss of 192 lb. of air from 95 to 32 deg. F. plus the heat loss of 6.07 lb. of steam from 95 deg. F. to water at 95 deg. F. plus the heat loss of 0.71 lb. of steam from 95 to 32 deg. F. plus the heat loss of 0.73 lb. of steam at 95 deg. F. to water at 32 deg. F., the figures are

$$\begin{aligned} 192 \times (95\text{-}32) \times 0.2375 &= 2{,}875 \\ 6.07 \times (1102\text{-}63) &= 6{,}307 \\ 0.71 \times (1102\text{-}1073.4) &= 20 \\ 0.73 \times (1102\text{-}0) &= 804 \\ &\hline \\ &10{,}006 \end{aligned}$$

To this must be added the motor heat losses which, at a motor efficiency of 92.8 per cent, would amount to 17 kw. or $(17 \times 3412) \div 60 = 967$ B.t.u. per min. This gives a total heat absorption of $10{,}006 + 967 = 10{,}973$ B.t.u. per min., or $10{,}973 \div 200 =$ very close to 55 t. of refrigeration effect. Power requirements would be $236 \div 55 = 4.29$ kw., or 5.75 hp. per ton of refrigeration effect. It is obvious that for certain requirements the compact arrangement and use of air for the cooling medium will offset the disadvantage of high power consumption.

Two Hundred Billion Ohms!

Ohms are common enough things in moderate quantity and the designer usually finds that he has more of them than he likes. But to assemble an unusually high resistance is often difficult. One of Edison's difficulties with the incandescent lamp was to make a filament of as high a resistance as 200 ohms. Wire is a convenient material for resistors up to about a megohm (one million ohms) where it becomes impractically long and thin. Impregnated clay, and marks made by a lead pencil, run up to scores of megohms and are also left behind. The scientist who wants a resistance much higher than these faces a problem, especially as most of them are quite variable.

Recently, Dr. Rentschler of the Westinghouse Electric and Manufacturing Co. has produced resistors, constant and reliable, of 235,000 megohms—over two hundred billion ohms!—and believes that units of a million megohms are possible. The device, enclosed in a glass bulb, consists of a helix of glass rod surrounding a straight rod of carbon. A thin film of carbon is "sputtered" on the glass helix. The conductivity of such a device is comparable to that of a dry porcelain line insulator, and is far less than that of a good, dry piece of one-inch board. An ordinary window pane on a summer day might transmit a thousand times as much current! These extremely high resistors are used as grid leaks in Dr. Rentschler's studies of photo cells. With them, photo-electric currents of one-ten-millionth ampere can be employed 10,000-fold in one operation.

According to Dr. E. T. Bull, professor of mathematics in the California Institute of Technology, any normal boy or girl of sixteen could master the calculus in half the time often devoted to stumbling through Book One of Caesar's Gallic War.

ELECTRICAL PRECIPITATION

A brief survey of fundamental theory of Electrostatic Precipitation and a description of experimental investigations by A. W. Simon and L. C. Kron

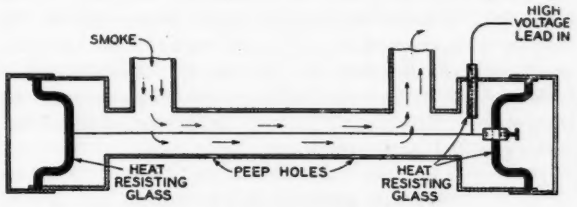


FIG. 2. COTTRELL ELECTRICAL PRECIPITATOR USED IN THE EXPERIMENTAL WORK OF THIS ARTICLE

COTTRELL TREATERS or electrostatic precipitators as they are commonly known have found many applications in various industries for the recovery or removal of smoke, dust and fume particles from their containing gases. In the power plant field, particularly in central station plants, this type of dust removal equipment is one of the very few that have been successful. Notwithstanding this extensive use, the fundamentals of this process have received but scant attention.

In order to put this process upon a more quantitative basis, A. W. Simon and L. C. Kron, both of the Tennessee Coal, Iron and Railroad Co., of Birmingham, Ala., undertook an experimental and theoretical study in which they investigated the effects upon the precipitation efficiency (percentage removal) of various fundamental variables, such as the operating voltage, secondary current, gas velocity, concentration of the dispersoid, size of discharge electrode and other factors.

The results of these experiments and investigations were presented recently in a paper by the investigators before the winter meeting of the American Institute of Electrical Engineers in New York.

As pointed out in this paper by the authors, the underlying theory of the process has been covered in a number of previous publications but the mechanism of the action in electrical precipitation is clearly expressed in the following excerpt from an article by Ross B. Rathbun on Electrical Precipitation of solids from Smelter gases.[1]

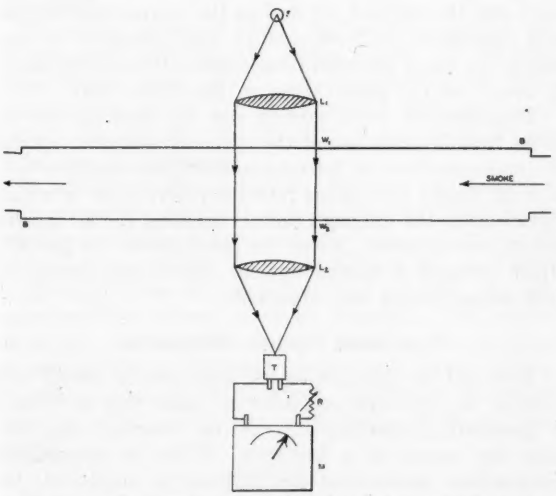


FIG. 1. SCHEMATIC DIAGRAM OF LABORATORY SMOKE CONCENTRATION METER

"This (the precipitation) is accomplished through the ionization of the gas which carries the particles in suspension. It is assumed that the negative iron or electron is the ionizing agent and that the velocity of the electron stream is sufficient to ionize the gas molecules by collision in a relatively small zone near the discharge electrode where the potential gradient is steepest. This stream of electrons in making its way toward the opposite electrode is assumed to charge the minute dust particles in passing by contacting or attaching to the particles. The latter having acquired a negative charge and being in a strong electrostatic field, are attracted by the positive pole and hurled against it with considerable force, where they give up their negative charge to this electrode and cling to it (the electrode) by adhesion."

The process, therefore, may be seen to consist simply of passing the fume laden gas through a unidirectional electrostatic field in which a corona discharge is maintained. The dust particles first are charged by the electric field and then swept out of the space between electrodes.

Theoretical development of this discussion is based upon the assumption that the chance of a particle being precipitated depends merely upon its chance of encountering an ion and this led to the equation

$$n = 1 - e^{-at} \quad \ldots\ldots\ldots \quad (1)$$

where n is the percentage removal (expressed as a fraction) t, the treatment time a, a constant for a particular precipitator treating a given fume or dust, and e the base of the hyperbolic system of logarithms. This equation enables an immediate deduction of the effect of the distance L traversed by the gas in the precipitator and the gas velocity V, since the time t is merely the quotient of these two. This leads to the equation

$$n = 1 - e^{-\frac{aL}{V}} \quad \ldots\ldots\ldots \quad (2)$$

From equation 1 also the effect of increasing the effective cross-section of a treater or its length or the equivalent process of connecting similar treater units in parallel or in series, can be deduced immediately. Since time t

[1] A. I. E. E. Transactions Vol. 41. 1922 p. 816.

is the only variable factor appearing in the right-hand member of equation 1 for a given constant gas volume treated per minute in a given number of precipitators, how these are connected has no import as regards the resulting efficiency, for the length of the path is increased in a series connection in the same ratio as the velocity is decreased in a parallel connection. In other words, a given number of units can be connected all in series or all in parallel without any difference in the theoretical efficiency. This also holds for symmetrical series parallel connections.

Special Apparatus Developed

One of the chief difficulties in experimenting with the action of the Cottrell treater has been the lack of a quantitative method of determining the instantaneous dust or smoke content of the gas entering or leaving the precipitator. In these experiments this difficulty was solved by means of an optical (photometer) method;

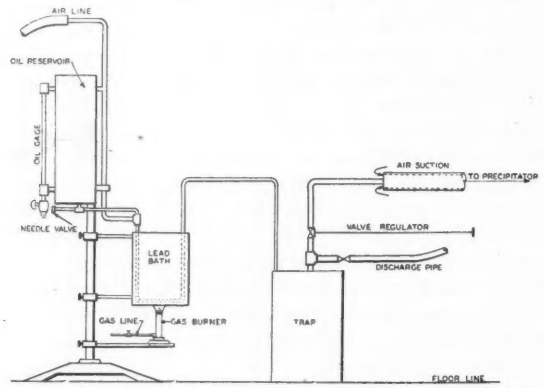


FIG. 3. SCHEMATIC DIAGRAM OF SMOKE GENERATOR USED IN THE EXPERIMENTS

specifically, by measuring the light absorbed by a definite column of the smoke-laden gas. For a dust of constant composition and physical characteristics, it can be shown that the concentration is proportional to the logarithm of the ratio of the incident to the transmitted light. The factor of proportionality depends upon the nature of the dust or smoke to be measured.

Apparatus used for measuring the dust concentration is shown schematically in Fig. 1. Light coming from small lamp s is rendered parallel by the lens L_1, then passes through the window W_1 into a long rectangular box B carrying the smoke-laden gas; from a second window W_2 on the other side of the box the light emerges, reduced in intensity by a fraction depending upon the concentration of the smoke; then by means of a second lens L_2 the light is concentrated on a light-sensitive element which sends a current through the meter M proportional to the intensity of light acting upon it. Two such metering devices were used, one on the inlet and the other on the outlet side of the experimental precipitator.

The experimental precipitator used is shown diagrammatically in Fig. 2. It consists essentially of a cylinder (pipe) with an insulated wire electrode stretched inside along its axis. The wire is held in place by heat-resisting glass insulators at either end, the necessary corona-forming potential being supplied by a lead brought into the cylinder through a bushing also of heat-resisting glass. The high voltage supply consisted of a pulsating direct current obtained from a half-wave vacuum-tube rectifier.

For the material to be precipitated, oil smoke was used, this being generated by a specially designed "smokifier" which allowed the formation of a constant stream of smoke of constant characteristics. This device consisted merely of a copper U-tube immersed in a molten lead bath; smoke was formed by simply feeding a thin stream of oil into the hot tube; the resultant smoke was blown out by a stream of air. Strictly speaking, this device generates an oil "mist" rather than a true smoke, the oil itself not being carbonized but merely vaporized and recondensed in the precipitator.

Ironically, while it is fairly easy to produce smoke, it is by no means an easy task to produce a *constant* source of smoke of *constant* characteristics, *i. e.*, to produce a smoke both the quantity and quality of which are controlled, and furthermore one which will not coat the windows of the measuring apparatus.

After much experimentation the scheme finally adopted was a modified form of the one originally developed by Tolman and his colleagues in their experimental study of smokes. The "smoke" strictly speaking, mist-generating apparatus is shown in Fig. 3. The material "smokefied" was lubricating oil just as in Tolman's work. Oil is dropped at a regulated rate into a copper U-tube immersed in a lead bath maintained at a temperature of 480 deg. C. by means of a Bunsen burner and thus vaporized, while a stream of air is blown simultaneously through the U-tube; this air stream recondenses the oil in the form of a fine mist and serves to carry it out of the apparatus.

The amount of oil and air fed into the apparatus is carefully controlled and duplicated by means of needle valves fitted with graduated dials. The function of the various parts of the smoke generator will be clear from the accompanying figure.

Inserted between the generator and the electric precipitator, however, is a galvanized iron tank which serves the double purpose of an equalizer or mixer and a trap for the larger droplets. This tank is provided with two valves by means of which the amount of smoke fed into the precipitator is regulated, the unused portion being allowed to escape to the outer air.

By duplicating the air pressure (read on a manometer) and the oil feed, as well as the temperature of the bath, smoke of uniform quality and quantity is produced, the exact concentration required being regulated by means of the gate valves on the mixer tank.

Experiments were carried out by passing the oil smoke first through one of the specially designed optical photometers where its initial concentration was observed; next the smoke was passed into the precipitator to which variations in the different factors involved in the investigation were applied. From the precipitator the gas was piped through a second optical photometer where its final concentration was observed.

The High-Tension Generator

It would be desirable to use high-tension direct current for the experiments; however, since this is difficult to generate, pulsating alternating current was rectified by means of a kenotron. While in commercial installations mechanical rectification is employed, the mechanical rectifier with its attendant sparking complicates the phenomena by introducing considerable high

frequency into the circuit; however, a more serious drawback is that with mechanical rectification a considerable and variable fraction as high as half of the secondary voltage is across the mechanical rectifier, and this fact complicates the voltage measurement. In the case of the kenotron it may be assumed that there is a negligible drop across the kenotron during the transmitting cycle, so that the secondary voltage can be calculated from the applied primary voltage or in most cases the phenomena can be expressed directly in terms of the primary voltage, to which the secondary voltage is simply proportional.

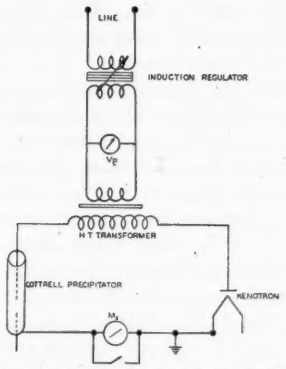


FIG. 4. DIAGRAM OF HIGH TENSION CIRCUIT EMPLOYED IN THE EXPERIMENTAL WORK

The secondary current was measured by means of a direct current milliammeter. It would have been better, of course, to use double-wave rectification, however, it is not likely that the phenomena would be essentially different, and single wave rectification was chosen for the sake of economy.

A wiring diagram of the high tension circuit is shown in Fig. 4. The kenotron was rated at 30,000 v., 100 milliamperes, although only about 1 milliampere was used in the experiments. The voltage applied to the primary of the high-tension transformer was regulated with an induction regulator.

The amount of gas passing through the precipitator was determined by means of an orifice meter, the differential across the orifice being measured by means of a draft gage.

The set-up consisted of (1) the smoke generator, (2) the equalizer trap, (3) the orifice meter, (4) the inlet concentration meter, (5) the precipitator, (6) the outlet concentration meter, (7) an exhauster to draw the air through the system, (8) an outlet to the stack for the waste gas; all in series.

In setting up the apparatus, extended use was made of the laboratory supports and supplies furnished by the Gaertner Scientific Corporation of Chicago, to whom the authors extend thanks for the excellence and usefulness of this apparatus. In particular, for example, the concentration meters were made by mounting light source, lenses, etc., on Gaertner optical benches; the boxes of the meters, the precipitator, the orifice meters, piping, etc., were mounted on Gaertner University laboratory supports, which were found extremely useful and convenient.

Results

In general, the experiments showed that the precipitation efficiency increases with the treatment time, voltage, current, and power, according to a curve which partakes of the nature of that for a condenser charge; or, in other words, they are exponential relationships. Curves representing these relationships thus rise steeply at first but at a continually decreasing rate; then bend over and eventually approach the value of 100 per cent efficiency asymptotically. This is depicted graphically in Fig. 5, which is a theoretical curve of the precipitation efficiency plotted as a function of the treater length. For a given gas volume treated per minute or constant gas velocity, the treater length is proportional to the treatment time. From this curve, it may be seen that in general the cleaner a gas becomes the harder it is to make it still cleaner. After the first 90 per cent of the smoke particles has been removed, just as much additional apparatus is required to remove an additional 9 per cent of the original content as was necessary to remove the first 90 per cent, and so on. From the theoretical point of view this is due to the fact that the cleaner the gas becomes (that is, the smaller the concentration of the dispersoid) the smaller becomes the chance of a single particle of the dispersoid encountering an ion.

In addition to the general results just outlined, certain other peculiarities of importance were noted. Surprising as it may seem, the value of the operating voltage, in so far as it determines the electric field, apparently has but little effect upon the cleaning efficiency. The function of the field is only to sweep the particles, once they have become charged, to the collecting electrode; for this purpose over a wide range the exact value of the field and consequently of the applied voltage is of secondary importance. The same holds for the size of the discharge electrode; the latter merely determines the operating or corona-forming voltage.

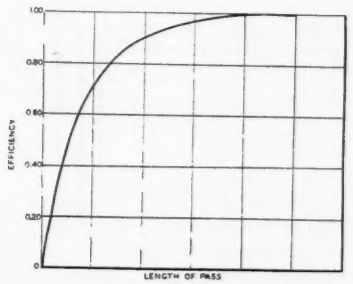


FIG. 5. THEORETICAL PRECIPITATION EFFICIENCY (PERCENTAGE REMOVAL) OF A COTTRELL TREATER AS A FUNCTION OF THE LENGTH OF THE TREATER

Of fundamental importance, however, is the current flowing between electrodes and through the smoke-laden gases within the precipitator; and for different discharge electrodes and operating voltages it was found necessary only to duplicate the current to duplicate the precipitation efficiency. The current itself is affected by the concentration of the dispersoid entering the precipitator, being considerably depressed if the concentration is high, and *vice versa*. The resulting corona characteristic (current-voltage curve) of the precipitator under load thus depends upon the concentration of material entering the precipitator.

While the present theoretical and experimental study, is thought to be more extensive than most others it is still far from complete.

POWER PLANT ENGINEERING April 1 1932

Parallel Operation of A. C. Generators

Part V.* Indicating relative speeds between three phase sources by means of lamps. Vector analysis of e.m.f. relations.

By
E. H. STIVENDER

IN SYNCHRONIZING alternating current generators with the line by means of lamps, an interesting condition arises when the phase rotation of the incoming line is opposite to that of the line, for under these conditions the lamps by their sequence, will indicate whether the machine frequency is fast or slow relative to the line frequency.

Consider the circuit shown in Fig. 1 where the machine is properly phased out with the bus and B and C phases are crossed at the potential transformer secondaries. This circuit is sometimes called the glow lamp method of synchronizing. A vector diagram for the voltage relations of the generator e.m.f.'s, $E_{O'A'}$, $E_{O'B'}$, $E_{O'C'}$ and the line e.m.f.'s, E_{OA}, E_{OB}, E_{OC}, is shown in Fig. 1(a). The line e.m.f.'s are denoted by heavy lines.

The relations between e.m.f.'s in a circuit of this kind are such that the direction of $E_{O'A'}$ relative to E_{OA} are in opposing directions at synchronism, while the direction of $E_{O'B'}$ is in the same direction relative to E_{OC} as in E_{OB} relative to E_{OC}. Likewise E_{OB} is in the same direction relative to $E_{O'C'}$ as is $E_{O'B'}$ relative to $E_{O'C'}$; hence the vector diagrams to illustrate the voltages across the lamps, L_2 and L_3, are more clear when shown separate from those to illustrate the voltages across L_1.[1]

Voltage E_{L_1} between A and A′ is zero at synchronism, as is shown in Fig. 1(b), that between B and C′ (E_{L_2}) and C and B′ (E_{L_3}) is 100 per cent of voltage from line to neutral, as in Fig. 1(c). Considering the generator voltage vectors to be rotating counter-clockwise for a

*Parts I to IV appeared in the Oct. 15., Dec. 1, 1931, Feb. 1 and Mar. 1, 1932, issues, respectively.

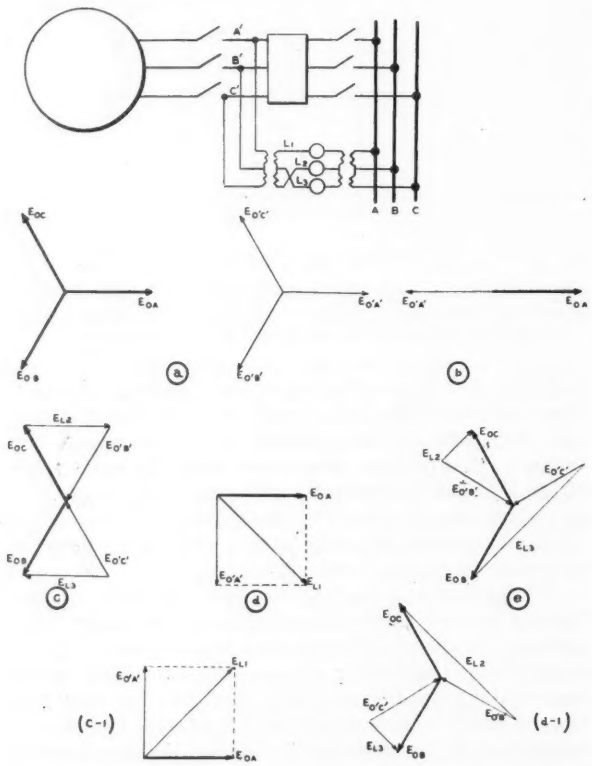


FIG. 1. A METHOD OF PRODUCING "FAST" AND "SLOW" INDICATIONS IN A THREE-PHASE CIRCUIT BY MEANS OF LAMPS

(a) Phase voltage relations of line phases (shown heavy) and generator phase voltages (shown light), at synchronism.
(b) Relations of phase A voltage at synchronism.
(c) B and C phase voltages at synchronism.
(d) Where generator phase A′ has become 90 deg. ahead of A.
(e) Where generator phases B′ and C′ have become 90 deg. ahead of B and C.
(c-1) Phase A′ is 90 deg. behind A.
(d-1) Phases B′ and C′ are 90 deg. behind B and C.

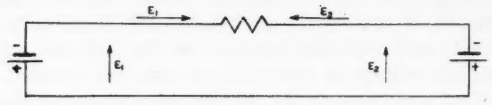


FIG. 2. AN ELEMENTARY CIRCUIT INDICATING THE VOLTAGE ACROSS THE SOURCES TO BE IN THE SAME DIRECTION, BUT ACROSS A RESISTOR OR SWITCH, THE VOLTAGE MUST BE REPRESENTED AS THE DIFFERENCE OF THE TWO SOURCE VOLTAGES

[1]In order to illustrate this statement, one might examine a simple circuit involving two batteries of equal voltage, such as Fig. 2. The voltage across the resistance R is zero but since voltage is present across batteries 1 and 2, we must consider the voltage across R as being composed of the two battery e.m.f.'s, E_1 and E_2, and be the difference between two equal e.m.f.'s which are in the same direction. Likewise it is apparent that the voltage from either battery positive to either side of the resistor is in the same direction.

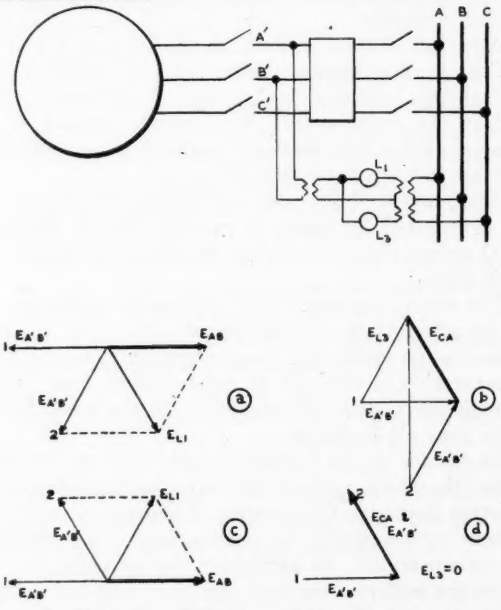


FIG. 3. A CIRCUIT WHERE RELATIVE GENERATOR AND LINE FREQUENCIES MAY BE OBTAINED WITH TWO LAMPS FROM THE STANDARD POTENTIAL SECONDARY CONNECTION

(a) Relations between voltages $E_{a'b'}$ and E_{ab} at synchronous position, (position 1), and $E_{a'b'}$ is 60 deg. ahead of synchronism, (position 2).
(b) Relation between $E_{a'b'}$ and E_{ca} at synchronism (position 1). and when $E_{a'b'}$ is 60 deg. ahead of synchronous position (position 2).
(a-1) When $E_{a'b'}$ is 60 deg. behind synchronous position.
(b-1) Relations of $E_{a'b'}$ and E_{ca} when $E_{a'b'}$ is 60 deg. behind synchronous position.

speed higher than line frequency and clockwise for a speed lower than line frequency, we see that when the generator is 90 deg. ahead of line frequency, E_{L_1} has increased to 141.4 per cent of E_{OA} in Fig. 1(d). E_{L_2} has decreased to zero and risen to 51.7 per cent, and E_{L_3} has risen to 193 per cent; hence, when the generator is running faster than synchronous speed, the lamps will rise and fall in brilliancy in the order L3-L1-L2, or its equivalent, L1-L2-L3.

In Figs. 1(c-1) and 1(d-1) the generator has fallen back 90 deg. from synchronism, making E_{L_1} = 141.4 per cent, E_{L_2} = 193 per cent, and E_{L_3} = 51.7 per cent, thereby causing the lamps to glow in the order L2-L1-L3, or L3-L2-L1, this being the opposite sequence to that previously indicating the generator was faster than synchronism.

By substituting capacitance transformers in the circuit of Fig. 1 and using low energy lamps connected similar to L_1, L_2 and L_3, an inexpensive glow-lamp method of indicating phase relation between high voltage circuits is obtained. The capacitance transformers may consist of bands of copper around the high voltage bushings of an oil switch.

Other methods of indicating phase relations by means of lamps may be devised, for instance in Fig. 3, B and B′ are connected together in a common grounded circuit as that of the usual metering transformers, hence the voltages across the lamps will vary between zero and double secondary voltage of the transformers. At synchronism the voltage across L_1 will be zero while that across L_3 will be equal to secondary voltage, or in most installations, 110 v. If the machine is faster than line frequency the lamps will brighten and darken in the order L_3—L_1, if the machine is slow the order will be L_1—L_3. The vector relations are given in Figs. 3 (a), 3 (b), 3 (a-1), 3 (b-1). From these the values of the voltages across the lamps E_{L_1} and E_{L_3} are obtained; in Fig. 3 (a) and (b), position 1 gives the voltage values when the machine is passing through synchronism, E_{L_1} is zero and E_{L_3} is 100 per cent normal secondary voltage; at position 2, E_{L_1} is 100 while E_{L_3} is 173. Similarly, taking the values E_{L_1} and E_{L_3} at 60 deg. intervals while the machine is faster than line frequency these voltages will be: 0, 100, 173, 200, 173, 100, for E_{L_1} and 100, 173, 200, 173, 100, 0, for E_{L_3} respectively. It is noticeable that E_{L_3} reaches 200, 60 deg. before E_{L_1}, giving the order of brilliancy L_3—L_1. Likewise when the machine is slower than line frequency as in Figs. 3 (a-1) and 3 (b-1) the order of voltages is: 0, 100, 173, 200, 173, 100 for E_{L_1} and, 100, 0, 100, 173, 200, 173, for E_{L_3}.

Here it is seen that E_{L_1} reaches 200, 60 deg. before E_{L_3}, making the order, L_1—L_3.

Powdered Coal in the Coal Dust Engine

INVESTIGATIONS TO DETERMINE FUNDAMENTAL DATA FOR USE IN INVESTIGATING POSSIBILITIES OF THE COAL DUST ENGINE. BY TETSURO SUWA†

TO CONFIRM possibilities of the coal dust engine, combustion properties of various kinds of coal, lignite and charcoal have been investigated under high pressure. Auto-ignition temperature curves plotted from the data obtained indicated not only combustion characteristics of pulverized fuel and Diesel oil but also the influence of injection pressure, shape of nozzle, fineness of fuel and oxidation during storage.

The idea of driving Diesel engines with powdered coal is not new and the Rupa engine has indicated the industrial policies of the idea. For successful development, however, a fundamental knowledge of the combustion properties of powdered coal is required.

Special apparatus consisting of a combustion chamber in which temperature and pressure could be varied was used to test the various fuel samples. Using this apparatus for determining the self-ignition temperature of various fuels, it was found that there is a marked difference in the self-ignition temperatures, depending on the type of fuel. It also appeared to the author that ignitibility is closely related to the percentage of volatile matter in coal and lignite.

Combustion time is reduced with increase of temperature and the character of the reduction varies with the type of fuel. Fuels of low self-ignition temperature are likely to have a greater rate of reduction, while the combustion time of Diesel oil remains almost constant.

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*Abstract of paper presented at Third International Conference on Bituminous Coal, Pittsburgh, Pa.

All the experiments described above were carried out under a pressure of 10 atmospheres (142.2 lb. per sq. in.) but as the combustion properties change with pressure, additional experiments were made under various pressures, namely 5, 10, 15, 20, 25, 30, and 35 atmospheres (gage pressure), respectively. These test results afford evidence that the auto-ignition temperature decreases rapidly with an increase of pressure, especially within the range lower than 10 atmospheres.**

The highest pressure rise was given at a pressure of 10 or 15 atmospheres with coal and at 25 or 30 atmospheres with charcoal. At the stated pressures, the analyses of combustion gases nearly coincided with the percentage of carbon dioxide and oxygen calculated from the compositions of the fuels. Analyses for No. 1 and No. 71 fuels are shown in this table:

Under 10 atmospheres		Percent CO_2 Calculated	Percent CO_2 Analysis	Percent O_2 Calculated	Percent O_2 Analysis
No. 1	At 350 deg. C.	11.07	9.80	9.57	9.85
	At 465 deg. C.	8.90	11.88	8.25	8.30
No. 71	At 310 deg. C.	8.20	6.54	10.11	11.40
	At 345 deg. C.	8.90	8.71	9.40	9.60

Depression of the auto-ignition temperature is very remarkable with coal or charcoal and coal No. 28 ignites at a temperature lower than that of low-temperature tar distillate under pressures higher than 20 atmospheres. It was found, in a previous investigation at the author's laboratory, that this coal could be used in a Diesel engine without any difficulty, even under heavy load.

**The atmosphere is usually calculated in kilograms per square centimeter, equivalent to 14.22 lb. per sq. in.

The fact that the auto-ignition temperature of pulverized fuel is remarkably depressed under high pressures suggests that the coal-dust engine should have a compression ratio higher than that of ordinary Diesel engines in order to secure the easy and complete combustion of fuel. In this connection, a system having a combustion chamber is desirable in the design of the coal-dust engine. A high compression ratio and a precombustion chamber may increase the cost of construction but it will be quite a small factor compared with the total cost.

Finally, the combustibility of pulverized fuel is naturally influenced by the degree of fineness or the size of the particles, as shown in the following table:

Fineness	5 atm.	10 atm.	20 atm.	30 atm.
	Ignition Temp., Degrees C.			
100- to 200-mesh	544	510	488	439
200- to 250-mesh	510	465	438	420
250-mesh and over	493	438	404	394

So far as the combustibility is concerned, it is desirable to pulverize coal as fine as possible. But it must be borne in mind that such a fine powder as will pass through a 250-mesh sieve cannot be stored for a long time, because it tends to absorb much moisture during prolonged storage and must be dried before use, which is accompanied by considerable elevation of the auto-ignition temperature. The temperature of drying also influences the rise of the auto-ignition temperature. The auto-ignition temperature of coal No. 1, for instance, was raised from 458 C. to 484 C. by heating at 200 C. for half an hour.

Vibration Troubles in Water Power Plants

HYDRAULIC UNBALANCE, NON-UNIFORM WATER PASSAGES AND OTHER FACTORS MAY CAUSE VIBRATION, FOR WHICH SOME REMEDIES ARE DISCUSSED. BY JOHN S. CARPENTER

MOST of the factors productive of more or less serious vibration in water power plants can be cured directly or indirectly; that is, the predominating cause can be removed or a combination of restraints can be introduced which will make the vibration negligible.

When vibration is due to turbine causes, it will usually be found that the runner is out of balance either statically, dynamically or hydraulically. There may also be a combination of hydraulic unbalance and unequally-adjusted gates. In almost every case the runner is statically balanced in the shop before shipment and it should remain in static balance unless welding has rendered it otherwise. The remedy in that case is to mount the runner on a piece of shafting and let it lie on leveled ways, so that the unbalance can be detected and corrected. In rare cases, runners are dynamically balanced, especially if they are of large diameter and high rotative speed. It costs quite a bit extra to do this work, as the machinery required is costly. There is little need to balance dynamically, however, if the runner has not been hydraulically balanced. Up to the present, not much attention has been given to hydraulic balance because its importance has only recently been appreciated.

Some time ago, a water wheel came to the writer's attention in which the number of buckets happens to be the same as the number of gates. There had been some vibration and the management had been told that it was a serious error to use a turbine with the same number of gates and buckets. The story goes that there is a "dead spot" in every revolution that causes a power fluctuation every time the gate tips and runner tips register. Investigation showed, however, that the runner discharge openings were not uniform all the way around. When these had been bent so that the bucket discharge openings were substantially alike all around the vane edge, the vibration stopped.

METHODS OF SECURING UNIFORM OPENINGS

When the combination of hydraulic unbalance and maladjustment of gates is found, a similar effect follows. In that case, when the large bucket discharge openings register with the large gate canals, there is a perceptible power increase for the moment. Also it is easy to see that when the small buckets register with the small gate canals there will be a momentary decrease of power. The cause of this is the fact that the cores of a solid cast runner may either swell or tilt in such a way that the resulting discharge channels may not be uniform. When that condition is found, the buckets can either be pried open slightly or hammered carefully shut, so that, on any plane through the discharge edges, the openings are substantially uniform. Thick tips on the gates tend to set up vibration if the runner condition happens to be critical.

When the runner buckets are made of forgings cast into a cast-iron hub and band, it is more difficult to get the openings uniform than with cored runners. This is because the plate steel forgings tend to distort in cooling from the shape they received in the forging dies. The distortion is not the same, even if the plates are placed in the dies uniformly as to direction of rolling. Reheating and reforging usually help this condition materially. When a runner with forged plate steel vanes is found to be out of hydraulic balance, careful heating and sledging of the large area buckets and prying open of the small ones will be found to reduce vibration greatly.

In some cases, vibration has been found to be caused by loose foundation bolts but that should not occur in any well managed plant. In all large installations, an effort should be made to isolate the turbine foundation from the building foundation as much as possible. It is seldom possible to do this as done with steam turbines but it would help if it could be done as well.

A choked draft tube has been found to set up vibrations; the remedy for this condition is obvious but each location presents some special factor to be handled.

In high-head plants, it has been found that long pipelines combined with "critical" turbines have caused many vibration troubles. One plant known to the writer was greatly benefited by installation of a slip joint near the power house. The packing in this joint was of hemp, which broke the metallic continuity from the turbine and the long pipeline. Vibrating noises thus were damped to an insignificant amount.

In some cases, vibration has been traced down to a generator rotor out of balance both statically and magnetically. In most cases the water turbine is blamed for everything wrong and the turbine builder is considered guilty on general principles until he has cleared himself, but the generator will bear checking up too.

The writer does not believe that it is necessary to have a certain number of gates more or less than runner buckets but he does believe that hydraulic balance should be more carefully investigated.

Creep of Metals at Elevated Temperatures

KNOWLEDGE OF ACTION OF METALS UNDER COMBINED INFLUENCE OF STRESS TEMPERATURE AND TIME NOT YET COMPLETE BUT TESTS ALLOW FAIRLY DEFINITE CONCLUSIONS TO BE DRAWN. BY P. G. McVETTY*

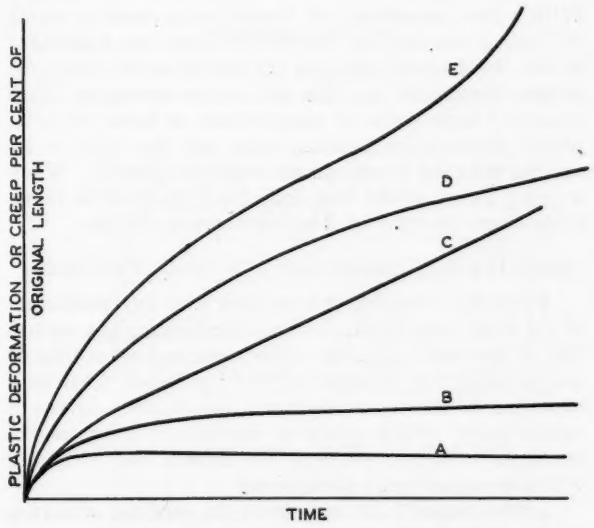
IN THE FIELD OF DESIGN, many important advances are waiting only for the development of reliable metals which may be depended upon to carry relatively high working stresses at temperatures from 750 deg. to 1200 deg. F. In many cases suitable materials are now available but it is necessary to choose the one best suited to the particular application and to assign to it a safe working stress. The latter requires consideration of corrosion and erosion which may reduce the cross section of metal carrying the load and metallurgical changes within the material which may change its physical properties during its life in service. To these must be added a generous allowance for the unfortunate fact that alloy steels suitable for high temperature applications have a tendency toward non-uniformity. As a result, the specimens tested may not truly represent the material in the section where stresses are maximum. If failure requires actual rupture of the metal the problem is often simplified, but if the allowable deformation within the expected service life of the material is extremely small, it is usually necessary to depend upon some form of long-time tension test or "creep" test to establish safe working stresses.

In the past six or seven years the term creep has become familiar to all engineers. In its simplest form, we may think of a vertical cylindrical rod supported at the top, carrying a constant load at the bottom and heated to some constant high temperature over a definite portion of its length. If means are provided for measuring with great accuracy any change in length of the section in which stress and temperature are maintained constant, data may be obtained from which the usual creep curve can be plotted. Forms which this curve may have depend upon the material, the temperature and the stress; the several types of curves are shown and will be discussed later.

From a consideration of this simple case, we may define creep as the plastic deformation of permanent set which results from the continued application of stress at elevated temperatures. The deformation during the application of the stress, which is usually a combination of elastic and plastic strain is purposely excluded to simplify this discussion.

From the practical standpoint, creep tests must be be limited in time and much depends upon the extrapolation of curves to times equivalent to the expected life of the material in service. It is, therefore, of great importance to develop rational concepts of the fundamental nature of creep phenomena. It is extremely doubtful if a study of the deformation of a material under constant stress and temperature during a limited period of time is, in itself, a sound basis for predicting the deformation characteristics of the material up to the end of its life in service.

Curve A represents a well known case. During the readjustment of stresses in many structures, members may be temporarily overloaded with the result that small plastic deformations occur. This frequently happens during the construction of a bridge. If the amount of such deformation is small, no harm results, as the deformation produces a small amount of cold work which slightly increases the strength of the material and decreases its ductility. In some cases of overloading in service this deformation may be considerable. Within limits, the tendency is for the material to increase in strength to meet the increased load upon it, resulting in a time-deformation curve similar to A in which apparent stability of dimensions is reached. If the load



CREEP OF METALS AT ELEVATED TEMPERATURES

is not further increased and if the strained metal is not exposed to elevated temperature, such stability may continue throughout the life of the part in service. If subsequent tests were made on this material in the same direction in which it was overstressed, it would be found to have higher strength and lower ductility than were obtained in the original inspection tests.

At elevated temperatures the problem is not so simple because exposure to elevated temperature tends to soften heat treated or cold worked metals. This leads to a condition represented by curve B. In this case, the change of slope of the curve is more gradual and a creep test may be prolonged for many months without assurance that stability has been reached. This is particularly true if the test apparatus allows very sensitive measurement of deformation and if creep is not masked by length changes due to temperature fluctuations during the test. The conduct of creep tests without the utmost precision of measurement and temperature control tends to give curves of form A instead of B. The danger involved in reporting tests indicating a stability which does not exist is often not fully appreciated.

*Research Laboratories, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa. From a paper presented before the Western Metal Congress at San Francisco, Cal.

Curve C represents the so-called first and second stages of creep. In the first stage, the slope of the curve gradually diminishes and this is followed by flow at a constant rate during the second stage. This form of curve has been used more than any other in published creep results and much significance is placed upon the slope of the curve in the second stage that is the creep-rate. If we look upon creep as a net effect of strain hardening and annealing, this is seen to be a special case in which the relation between the two opposing forces remains constant over a long period of time.

Curve D is one frequently obtained in practice. It is like curve B in form, but the plastic deformation is greater. In spite of the gradually diminishing creep rate it is usually conceded that stability will not be reached with this type of curve.

Curve E represents the condition of high stress or high temperature or both. The stage of increasing creep rate or third stage usually begins with necking of the test specimen and ends in failure. The inflection in this curve is easily explained on the basis of stress changes. With a few exceptions, all tensile creep tests in which the load is constant are assumed to have also a constant stress. As the test specimen extends, however, the cross section diminishes and the unit stress increases. With relatively high stress or temperature or both, the total plastic deformation becomes large and the error in assuming constant stress can no longer be ignored. When a creep curve shows this inflection, fracture is inevitable since the rate of flow increases to failure.

Metallurgical Significance of Creep Phenomena

From the foregoing it is evident that any prediction of the total creep within a time representing the service life of the metal requires a thorough understanding of the metallurgical changes which may result from long exposure to stress at elevated temperatures. Even a casual study of this phase of the subject indicates the enormous influence which grain growth and softening will have upon creep phenomena.

Let us consider for a moment the internal structure of our metals. The miscroscope reveals crystals having random orientation between which is found an intercrystalline material which may be either a so-called amorphous cement or possibly finer crystals which are too small to be resolved by present day microscopes. The amorphous cement theories may have to give way to the small crystal concept as a result of X-ray investigation of this subject.

If a specimen is stretched at normal temperature, we know that plastic deformation results from slip along crystallographic planes which coincide with planes of maximum shear least favorably situated with respect to the principal stress. According to the slip-interference theory, slip is opposed at the grain boundaries, with the result that metals increase in strength as the grain size diminishes. Going in the other direction, single crystals are notably weak, but their loss in strength is somewhat compensated by a gain in ductility.

The slip-interference theory thus accounts for the fact that metals at normal temperature are strengthened by treatments which reduce the grain size. At elevated temperatures, however, there is now some evidence that metals are weakened by reducing the grain size. This may be due to the relative volume of material within and between the crystals. Carried to the extreme case, we would expect single crystals to have high resistance to creep. Experiments in this direction are now in process.

Regardless of size of crystals, fracture at normal temperatures is generally intracrystalline. At high temperatures, on the other hand, we frequently find intercrystalline fractures. This leads to the idea of an equicohesive temperature at which the crystals and the material between them have the same strength. Theoretically, fracture will occur through the crystals themselves below this temperature and between the crystals above this temperature.

In the present state of our knowledge, it is impossible to say whether creep is due to slip within the crystals, to plastic flow of the intercrystalline material, or to a combination of the two. Tests at normal temperature tend to support the first view, tests at very high temperatures the second, and a large number of intermediate tests appear to fall in the third class Furthermore, the location of the equicohesive temperature itself is uncertain and appears to be very much influenced by the past history of the material. It is, therefore, quite possible that the laws which appear to govern creep phenomena during relatively short tests may change appreciably after long exposure to high temperature and stress. Since such changes are possible, great care must be used in the extrapolation of creep curves.

So far we have considered only the cold work due to creep itself and the subsequent removal of this strain hardening by thermal influence. We may have in addition the effects of previous cold work such as rolling below the critical temperature or any other treatment which leaves internal stresses in the metal. In general, the greater the amount of cold work, the lower will be the temperature which will cause softening, or the shorter will be the time required to produce softening at a given temperature.

Heat treated materials also have a tendency to be unstable if subjected to long exposure to stress at elevated temperature. It is often claimed that a material which has been quenched and drawn may be exposed to any temperature below the drawing temperature for any length of time without further softening. Experiments show that this is not true and the stability of heat-treated as well as cold-worked materials at high temperatures is open to considerable doubt. In many cases the time required is extremely long but the study of thermal effects must give due consideration to the time of exposure to the high temperature.

Another metallurgical change which has a great influence on creep tests is the age hardening of certain alloys. This may not only reduce the creep rate to zero but actually cause contraction of the test specimen. This phenomenon is due to precipitation of certain constituents accompanied by increase in strength and decrease in ductility; however, the added strength from this change approaches a maximum after which further exposure to elevated temperature results in a decrease of strength. Alloys in this class might easily show stability during a long period of test after which creep would start and proceed at an increasing rate.

When creep tests were first made, the idea prevailed that there was a determinable "creep limit stress" for a given material at any temperature. It was assumed that stresses above this limit would result in continuous

plastic deformation, while below this limit stability of dimensions might be expected. To a certain extent, this idea still exists and we find a demand for creep limits which will yield safe working stresses upon application of a suitable factor of safety. Unfortunately, the bulk of experimental evidence indicates that real creep limits do not exist. The tendency is to design on the basis of maximum allowable deformation and this requires the reliable determination of creep rates by carefully conducted tests. Since practical considerations limit the length of such tests, extrapolation of creep curves is necessary. It should be remembered, however, that many factors affect such extrapolation in addition to the length of straight-edge available. It behooves the designer to adopt a critical attitude toward extravagant claims for the large number of alloys now on the market. It is quite possible that our greatest need is for more knowledge of present metals rather than for a marvelous material with properties exceeding our greatest expectations.

Power Storage by Pumping

Improvement in Load Factor and in Efficiency of Plants and Transmission Lines

BETTER LOAD FACTOR, so that run-of-stream, power which would be wasted can be saved and fuel-fired plants can be run at better efficiency for longer periods, is an end greatly desired and much sought. While increase of steady load will do much, peaks of demand will always exist, so that storage of energy during light load periods to be utilized during the peaks will be effective in an increasing economy.

So far, direct storage of electrical energy has been possible only in storage batteries, a method which is quite efficient but limited in capacity by the cost of the installation.

Storage of heat energy in water, either that from excess boiler and exhaust steam or that transformed from electrical energy is quite efficient, if the storage period be for a few hours but again has limitations, the largest plant, Ruths accumulators at Charlottenburg, being 67,000 kw-hr. Within its range, heat storage has wide applications and has shown its ability to increase plant economy satisfactorily.

While pumped water storage has somewhat lower efficiency, 60 to 65 per cent, the only limitation as to size is the amount of investment in high-level reservoir and in pumping and regenerating plant which can show economy. This will depend on the off-peak capacity available, the ratio of value of peak-load energy to cost of off-peak generation and the cost of building reservoirs and plant. In case a suitable location for storage is available near the load center and transmission from the primary plant is long, cost of the storage plant may be partly offset by reduced cost of the long transmission line, whose capacity may be reduced by the peak-load current supplied from storage. Where large capacity can be secured in the high-level reservoir at moderate cost, seasonal storage may add materially to available hydraulic plant output and reduce the investment needed for standby fuel-fired plant. Also the standby plant may be run at efficient load whenever it operates, utilizing part or all of its output to store as much hydraulic energy as system economy requires.

For an average city plant, the load demand may be over a range of 27,500 kw. in the early morning to 190,000 kw. at the afternoon peak, with average of 109,000 kw. Here the peak would be 175 per cent of average and 600 per cent of minimum demand, being above the average for 13½ hr. and below the average for 10½ hr. By storing during low load and regenerating during high load, the average load can be raised to 120,000 kw. bettering the load factor by 6 per cent.

Interconnection

By interconnection of supply systems to loads of varying character, the effectiveness of storage may be increased. Figure 1 shows the time variation of peak in different communities. Curve 1 is for a small town having little industry; curve 2 for a small industrial town; curve 3 for supply largely to agricultural districts. Note the difference in times at which peak demands occur but that low-load on all is from 9 p. m. to 6 a. m. For a combined load, curve 4, an installation of 600 kw. capacity can store energy from 8 p. m. to 6:30 a. m. to the amount of some 2800 kw-hr. which, at 60 per cent efficiency would yield 1680 kw-hr. regenerated for peak load service, the balance being supplied by the generating plant running at 10 per cent above rating.

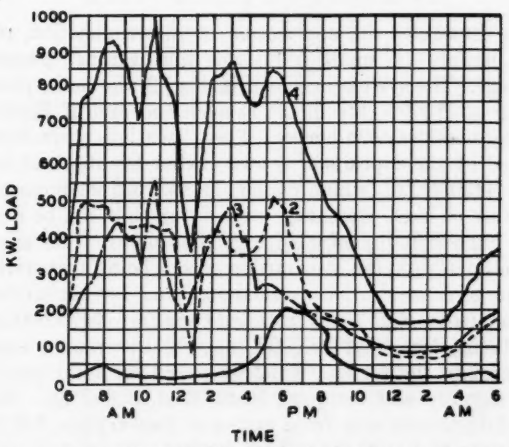


FIG. 1. LOAD CURVES VARY WITH THE CHARACTER OF THE DISTRICT SUPPLIED.

For the main generating system capacity required would be 600 kw., for the regenerating system 400 kw. or about the same total as for the main peak load. But both units will be run most of the time at high load factor and good efficiency and total capacity for the combined load will be 1000 kw. as against 1250 kw. required in separate stations.

On a larger scale, the system of Saxon Public Works,

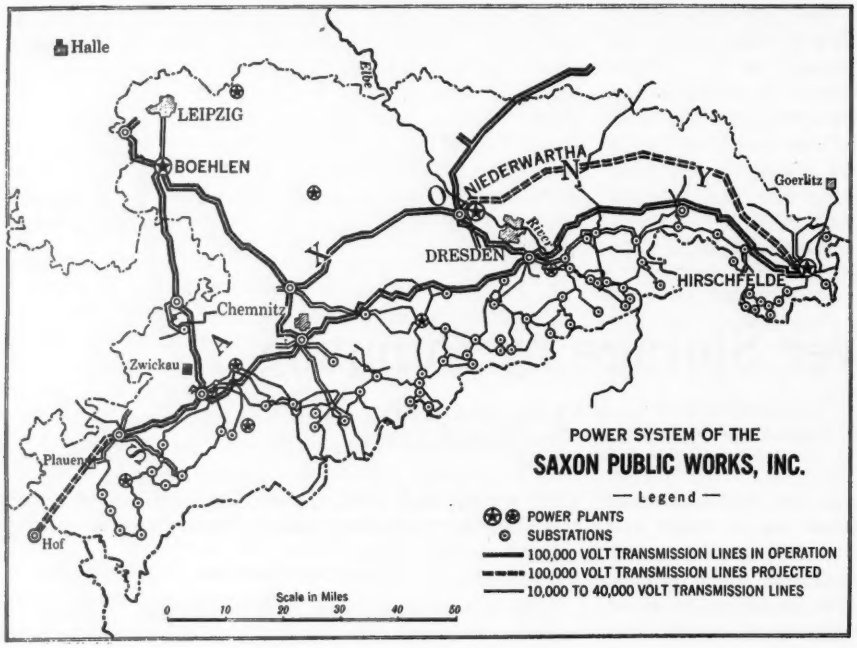
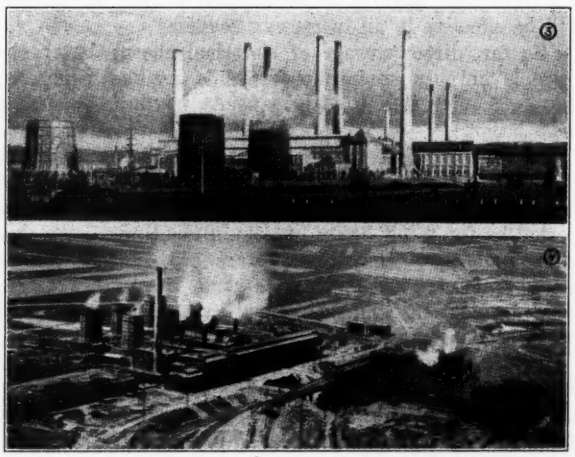


FIG. 2. STEAM MINE-MOUTH STATIONS AT BOEHLEN AND HIRSCHFELDE SUPPLY POWER FOR PUMPED STORAGE AT NIEDERWATHA

FIG. 3. HIRSCHFELDE STATION HAS INSTALLED CAPACITY OF 195,000 HP.

FIG. 4. PLANT AT BOEHLEN OF 281,000 HP. WITH BRIQUET FACTORY AT THE RIGHT



Interconnected Storage System

Inc., illustrates the application of interconnection, central supply to small industries and central pumped storage. The system is shown in Fig. 2, the main plants being at Hirschfelde in the eastern end and at Boehlen in the northwestern corner. These locations were determined by the deposits of brown coal or lignite, heat content 4150 B.t.u., which cannot be shipped economically because of high percentage of moisture but can be dried and burned at the mine with good economy. It is mined from open pits, the overburden of soil being transferred by large cranes to build reclaimed land for agriculture. Hirschfelde, Fig. 3, has installed capacity of 195,000 hp., Boehlen, Fig. 4, of 281,000 hp. Smaller plants incorporated in the system, which are used for local supply, for standby and for peak loads total 42,000 hp. They use bituminous coal from mines at Zauckerode, 185,000 t. a year of 10,500 B.t.u. heat content.

Near the center is the Niederwatha pumped storage station of 93,000 hp. present capacity, with 187,000 hp. ultimate, using 470 ft. head. The upper level reservoir has storage for 528 million gallons, yielding 560,000 kw-hr. on demand, the power for pumping coming from the two main stations during light-load periods. The lower reservoir is the same capacity as the upper and is kept filled by a small unit pumping from the river Elbe. Details of this plant were shown in the June 1, 1931, issue, p. 598. The equipment is four sets of pump,

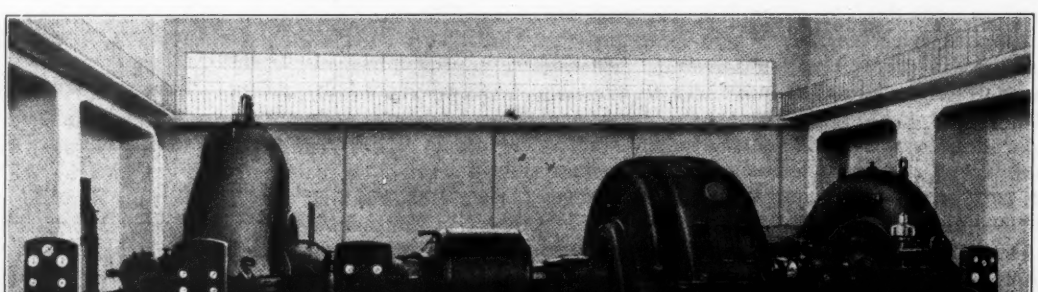


FIG. 5. PUMP TURBINE SETS OF 27,000 HP. EACH ARE USED AT NIEDERWATHA

motor-generator and turbine, Fig. 5. Each pump has capacity of 140,000 g.p.m. at 458 ft. head or 160,000 g.p.m. at 453 ft. head and requires 27,000 hp. to drive. Motor generators are rated 15,000 kw. each and water turbines 30,000 hp. each.

Saxony is densely occupied by small industries requiring skilled work such as clothing, furs and printing at Leipzig, machinery, clothing, cigarettes and porcelain at Dresden, machinery and vehicles at Chemnitz, laces and porcelain at Plauen. Factories, on the average, employ 200 to 500 workers. So closely are the industries concentrated, however, that a population of 5,000,000 lives in an area the size of Massachusetts and of these 1,600,000 are employed in industries. To supply power to the industries, a network of 3,573 mi. of circuit is used, 2,073 mi. being high tension with 359 mi. operating at 100,000 v. This 100,000-v. system is also connected near Leipzig with the lines of the Government Elektrowerke to the north, the Berlin system to the northeast and will be joined to the Bavarian state system to the southwest, so that power can be interchanged in emergencies.

An interesting by-product is the manufacture at Boehlen of 455,000 t. a year of briquets for household use, the plant being seen at the right in Fig. 4.

New Hot Water Return Pump

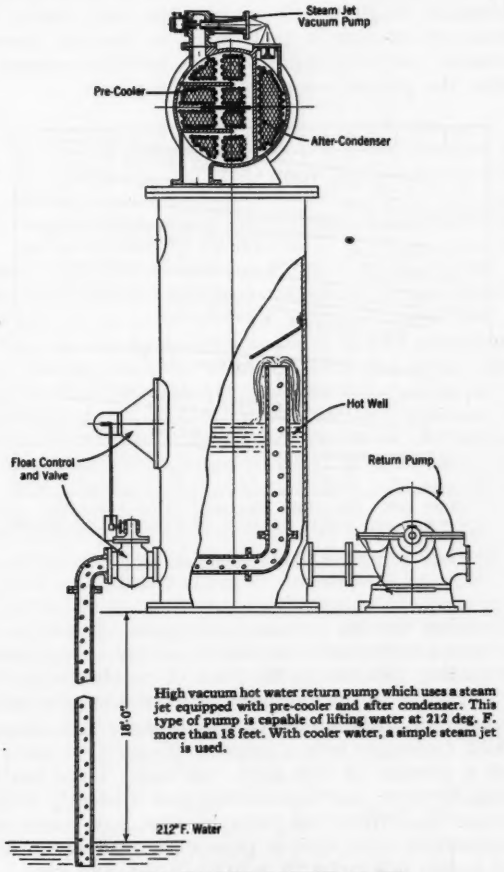
THERE ARE MANY instances in which hot water must be raised several feet from a hotwell to the pump. The accompanying diagram shows a pump which has been especially designed by the Foster Wheeler Corp. for lifting hot water under vacuum and which has been operating successfully for two years. The assembly consists of a centrifugal pump (or a direct acting steam pump where electric current is not available), a receiving tank and steam jet air pump, equipped with pre- and after-condenser. A float control valve may or may not be installed, depending upon operating conditions. The only moving part is the impeller of the centrifugal pump and float control valve, should one be used. It is suitable for use in connection with filters, vacuum heating systems, flat boxes, suction rolls and other service dealing with large volumes of air or vapor.

To start operation, the steam jet air pump is put into service creating a vacuum in the receiving tank and riser pipe. The vacuum extending to the surface of the water in the riser pipe makes some of the water flash into steam. Vaporization cools the water in the riser sufficiently to permit the vacuum to lift the water in the pipe. This operation is further assisted by the air-lift effect of the steam bubbles in the column of water in the pipe, so that actually, the water flows into the receiving tank before the vacuum alone would exert enough lifting force.

Steam flashed from the water is condensed in the steam jet precooler and the noncondensables removed by the jet so that the vacuum is maintained. The heat of the vapor condensed in the precooler may be saved by having plant make-up water pass through the precooler.

Where the liquid is comparatively cool and does not tend to flash into steam under the vacuum required to lift it, a modification of the same type of pump may be used. This modification is used successfully in filtering under vacuum, in paper machinery, such as flat boxes and suction rolls, and in save-alls and other vacuum filtration systems. Since most of the vaporization is eliminated, there is no need for the precooler, used to relieve the load on the steam jet vacuum pump in the hot water return pump.

This system is especially useful in large heating plants operating with a vacuum system, particularly where several buildings are heated from a central station and grade conditions necessitate pockets in return condensate lines. It is possible to secure enough vacuum to permit uninterrupted removal of condensation and



High vacuum hot water return pump which uses a steam jet equipped with pre-cooler and after condenser. This type of pump is capable of lifting water at 212 deg. F. more than 18 feet. With cooler water, a simple steam jet is used.

212-DEG. WATER LIFTED 18 FT.

air from the heating coils or radiators during any weather conditions. With proper control of vacuum and removal of condensate the central steam plant may control the heat as readily as if a hot water system were used.

Advantages of the new type vacuum return pump are simplicity of design, compactness, high capacity and high efficiency. The steam jet vacuum pump, operating without moving parts, requires little supervision and is compact. It also handles a maximum amount of noncondensables with a minimum power or steam consumption. The use of a suitable hotwell provides a positive gravity feed for the water pump and by flooding the pump inlet, eliminates the necessity of priming.

CAST IRON must be welded slowly. Forcing the work will cause the weld to pull away when cooling because of internal contraction strains.

POWER PLANT ENGINEERING April 1 1932

Benefits of Heating Air for Combustion

AS A MEANS OF RECOVERING HEAT FROM FLUE GASES THE AIR HEATER IN COMBINATION WITH AN ECONOMIZER HAS BEEN FOUND ECONOMICAL IN MANY PLANTS

IT HAS been shown in a great many instances that the most efficient installation is a combination of small air heater and an economizer. For this reason it is unlikely that a manufacturer would approach the design of a power plant except with the idea of developing a combination which would produce the best results, regardless of whether it took more or less air heater, economizer, turbine stage bleeding or other means to produce the greatest economy for the plant.

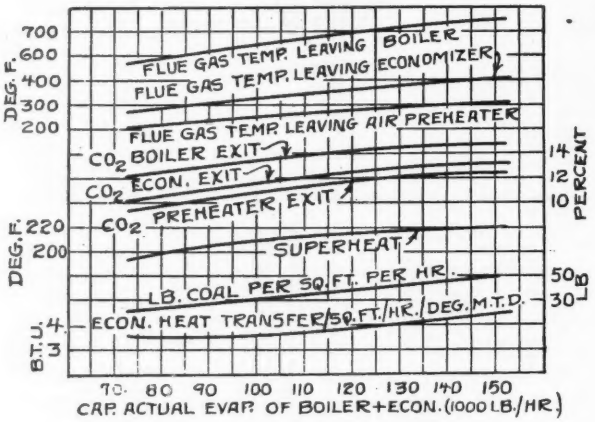


FIG. 1. TEST PERFORMANCE, BOILER NO. 2, UNIT NO. 1, CRAWFORD AVE. STATION

Heat lost up the chimney of a power plant has always been a large source of wasted energy. Any means of recovering this heat in the form of usable energy has been attractive to the engineer, hence the large number of economizer installations in this country and abroad, in which feedwater before entering the boiler is made to absorb a portion of this heat. In many large central stations, however, the feedwater is now efficiently heated by steam bled from the turbines. In such cases, air preheaters are often used to permit the recovery of heat which would otherwise be wasted in the flue gas.

Even with economizers installed, there is opportunity to recover additional waste heat by means of an air heater, as a result of the high ratings and consequent high boiler outlet gas temperatures which are becoming the rule in modern practice. When an integral economizer is installed in the last pass of the boiler, the outlet gas temperatures are frequently high enough to justify investment in an air preheater. A number of installations have also recently been designed with independent economizers and air heaters. Figure 1 shows typical conditions in such an installation.

AIR HEATER EFFECTS BENEFICIAL

Beneficial effect of the air heater extends considerably beyond merely recovering a certain number of heat units from the stack and reintroducing them into the stream of gas crossing the boiler tubes. It has been found that preheated air improves combustion, reducing the time for any particle of fuel to disintegrate and burn completely. Combustible in the ash is thus reduced and more fuel can be burned per square foot of grate area for the same furnace volume. Figure 2 shows results of tests on three boilers, demonstrating how combustible in the ash was reduced with increase in preheated air temperature.

Consideration must be given, of course, to the ability of the furnace itself to stand up under increased heat liberation made possible by use of preheated air. This contingency has made necessary the development of improved types of refractory material and, at the same time, has brought about the use of the water-cooled wall. Thus, with proper design to fit given conditions, full use can be made of the benefits of preheated air to improve combustion.

An air heater has an advantage of great importance as a heat recovery medium and that is that temperature differences are greater than in the case of the economizer. This important theoretical consideration, however, is subject to many practical qualifications, among which is the difficulty of carrying large air ducts from

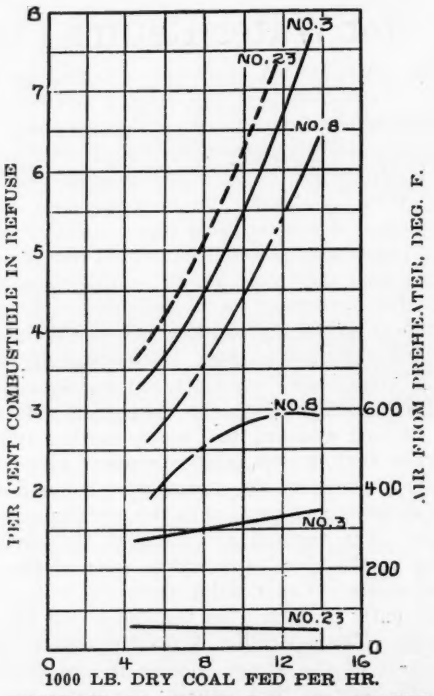


FIG. 2. INCREASE OF PREHEATED AIR TEMPERATURE ON TESTS OF THREE BOILERS REDUCES COMBUSTIBLE IN ASH. BOILERS AND STOKERS SAME SIZE

Boiler No. 3—Economizer and small tubular air preheater Boiler No. 8—Large tubular preheater only. Boiler No. 23—Economizer only. Air temperature is that of room; it decreased slightly during test.

the heater back through the plant to furnace without great heat losses due to radiation and leakage. Ducts for such purposes are sometimes made of insufficiently heavy material so that they may not have long life. Insulation of high temperature air ducts is expensive.

Despite the undoubted theoretical advantages resulting from the use of preheated air, careful analysis must be made, in any power plant design, of the entire plant

before it can be stated definitely whether or not air preheaters should be used. Their performance is closely interwoven with the operation of the entire plant. They are not only a part of the equipment used in burning the fuel but also form a factor to be considered in determining the amount of stage bleeding of main units. In short, they must be selected, like all other equipment, on a basis of final dollar economy. The really important result to be obtained is low cost of steam or electric power and this does not always accompany highest heat efficiency.

Types of Air Heaters

The tubular type consists of a group of tubes supported at each end in tube sheets. In the usual arrangement gas flows through the tubes and air outside and transfer of heat occurs through tube walls. The tubes may be either vertical or horizontal, as shown in Figs.

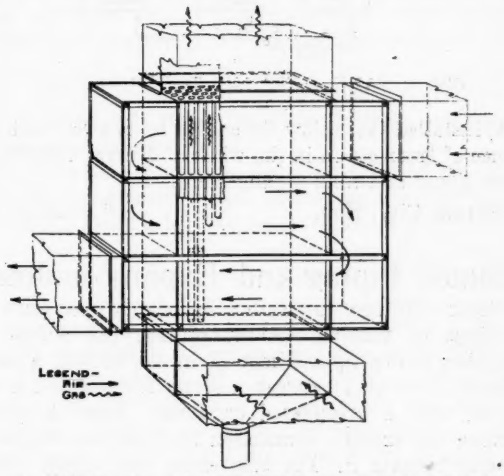


FIG. 3. TUBULAR AIR PREHEATER WITH VERTICAL TUBES

3 and 4. They are sometimes rolled into holes in the tube sheets like boiler tubes or a packed glandular joint is used to make a tight connection to cast-iron tube sheets. In this case tubes are easily replaceable without the special equipment necessary for cutting out and rolling in tubes and the gland permits tubes to expand as necessary. It is claimed for the rolled-in joint that it can readily be kept tight and that the flexibility of the steel plate tube sheet is sufficient to take care of all necessary expansion.

Plate type heaters contain a series of steel plates separated by spacers. Gas and air flow in alternate thin layers between the plates and transfer of heat occurs through the plates. Guide strips are often used in both gas and air passages to direct the flow of gas and air, and to prevent stratification and eddying. In the sectional form of plate air heater, plates are assembled in sections of standard size at manufacturing plants and shipped to point of installation in units ready to assemble in place.

Air heaters may fail through corrosion at the cold end. This is the result of temperatures falling below the dew point and causing moisture to collect on the heating surface. Presence of sulphur in the gases will then form sulphuric acid which, combined with the natural oxidation, due to the presence of water, will eventually corrode the tubes or sheets. In the case of plate type air heaters, designs are often used which provide for removing or reversing plates so that the cold end can be placed at the hot end and vice versa, after a certain amount of corrosion has taken place.

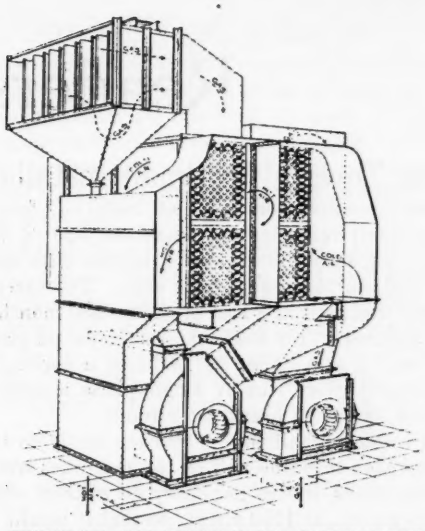


FIG. 4. TUBULAR AIR PREHEATER WITH HORIZONTAL TUBE ARRANGEMENT

Regenerative preheaters have elements which are alternately heated by hot gases and cooled by incoming cool air, so that a transfer of heat is effected from gas to air. In the most familiar form of this apparatus a rotor having its axis vertical is built up from a large number of plates alternately corrugated and flat, so that a great amount of heating surface is contained in a comparatively small space. Slow rotation of these elements carries them continuously from a stream of hot gas to a stream of cool air and back into the hot gas again. A cylindrical casing enclosing the rotor is divided into gas and air compartments which connect with the rotor by means of sliding sealed joints. Forced and induced draft fans, in one make of these units, are incorporated in the unit and are driven by the same motor that drives the rotating element. Another form of regenerative heater has stationary elements, gas and air being blown through them alternately by means of a system of automatic valves, Fig. 5.

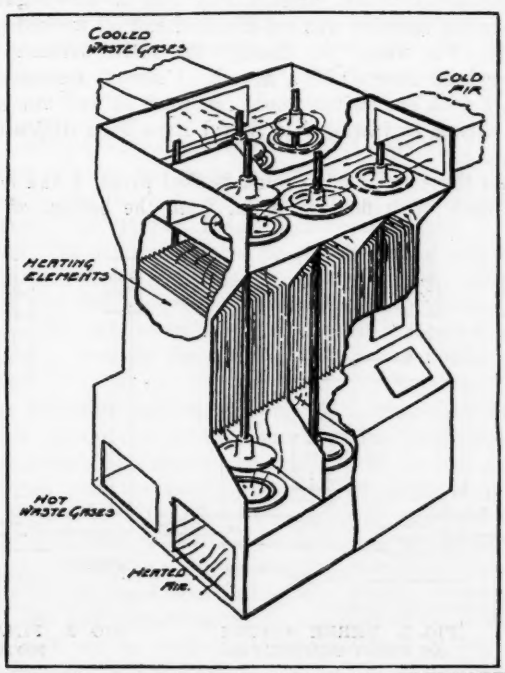


FIG. 5. ONE TYPE REGENERATIVE AIR PREHEATER

Readers' Conference

Cooling Towers for Small Installations

A NEIGHBORHOOD GROCER had installed, four years ago, two small refrigerating machines, one ¾ and the other ½ t. capacity. Both were equipped with shell condensers and spiral copper water coils. For three years, city water was used at a cost of $25 to $30 monthly during the summer. This made the refrigeration rather expensive and I was called in to build a cooling tower. Both machines were run by single-phase motors with a single-pole switch to break the circuit.

This being a small job, it was too costly to install a pump for each machine and as the machines would run at various times, it was necessary to connect the water pump, 14 g.p.m., at 1750 r.p.m., so that it would operate with either or both machines running. Water connections were, therefore, made to allow water to pass through both condensers whether both machines were operating or not.

My first thought was to connect the pump to each of the single-pole switches just as the machines were connected, as shown by Fig. 1. After connections were made, I found that when one switch was thrown in both machines would start with only the one switch closed. In looking this over, it can be seen that the current traveled from the one machine around the pump to the other machine.

When discussing the problem with talented electricians, some said to install magnetic switches on the pump, others said that there was no way it would work perfectly so I felt confident that single-pole magnetic switches properly connected would do. So they did. The machines were connected to break the circuit on the positive line. I connected the pump to break the circuit on the negative side, as shown by Fig. 2. The negative side to the machine was not changed and all worked perfectly. The water bill through the entire summer has never been over $1.00 a month. I see no reason why Fig. 3 with one switch would not work as well but with the wiring as installed it would have been difficult to make.

As these small units must be fool proof, I had a 50-gal. tank, with float set 6 in. from the bottom of the tank, installed just below the ceiling to do away with any chance of freezing up in the winter. Figure 4 shows the tower pump and tank arrangement.

Kansas City, Kan. J. F. STALEY.

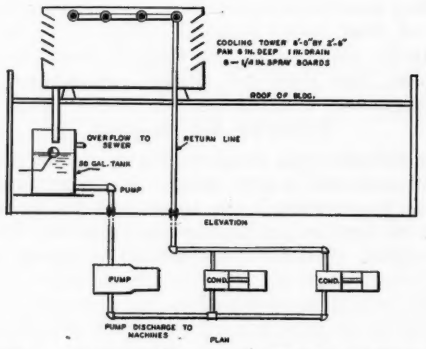


FIG. 4. TANK, PUMP AND TOWER LAYOUT

Exhaust Piping and Expansion Joints

SOME TIME ago, the writer, in looking over some old drawings of turbine exhaust piping, ran across the condition shown approximately in the sketch, a 36-in. exhaust connection between a steam turbine and a condenser, with a corrugated expansion joint, A, placed between the exhaust connection and the base elbow, B, directly beneath it. The base elbow was shown resting on a concrete slab 24 in. square by 18 in. deep—cast above the floor line as shown, but no bolts were shown, or specified, to hold down the base elbow.

The distance, center to center, from elbow B to elbow D was 12 ft. 8½ in., making the 36-in. spiral riveted pipe, C, about 8 ft. long, and weighing about $80 \times 80 = 640$ lb. Base elbow, B, weighs about 3000 lb. and the slab of concrete about 150 lb. per cu. ft. or $2 \times 2 \times 1.5 \times 150 = 900$ lb. The weight of the base elbow, B; spiral riveted pipe C, and concrete slab is, therefore about $3000 + 640 + 900 = 4540$ lb.

Area of the 36-in. exhaust pipe is given by $0.7854 D^2 = 0.7854 \times 36^2 = 1018$ sq. in., and if a 29-in. vacuum

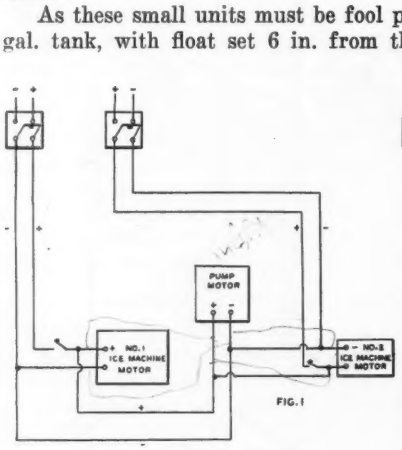


FIG. 1. THREE MOTORS AS FIRST CONNECTED

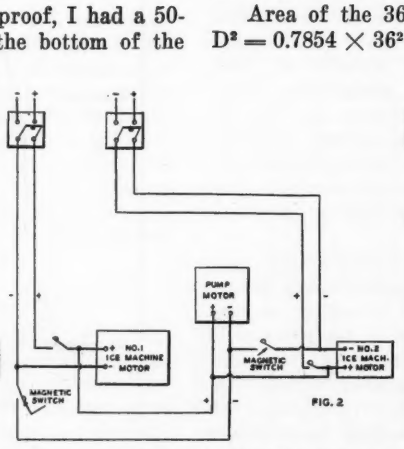


FIG. 2. FINAL AND SATISFACTORY MOTOR CONNECTION

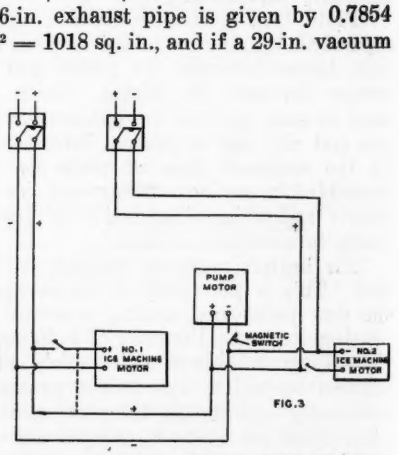
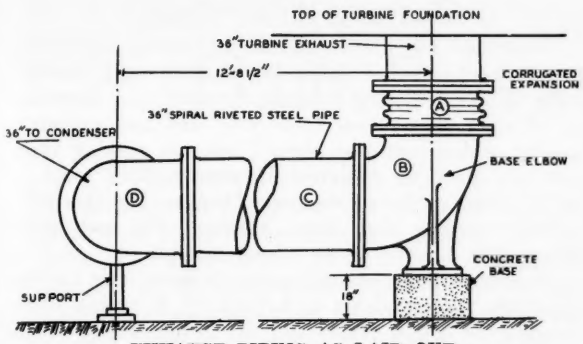


FIG. 3. UNDER OTHER CONDITIONS THIS CONNECTION COULD HAVE BEEN USED



EXHAUST PIPING AS LAID OUT

is maintained at the turbine exhaust the absolute pressure in pounds per sq. in., as obtained from the steam tables, would be approximately 0.489 lb. Subtracting this from the pressure of the atmosphere, we have a difference of 14.7 — 0.489 = 14.21 lb. per sq. in.; multiplying this by the area of the exhaust pipe, we have 14.21 × 1018 = 14,466 lb., to total pressure tending to collapse the expansion joint.

This is resisted, however, by the weight of the base elbow, pipe, and concrete slab (assuming the base elbow to be bolted down), leaving an unbalanced pressure of 14,466 — 4540 = 9926 lb. acting upward. The area of the base of the concrete slab, where it joins the floor line, is 24 × 24 = 576 sq. in. and the tensile stress in the concrete at this point (assuming the slab to have been cast to the floor after the floor was laid) which is probably the weakest part, is then 9926 ÷ 576 = 17.3 lb. per sq. in. approximately. If the slab is well bonded to the floor, there is no danger of separation at this low unit stress, but if the slab merely rests on the floor the total unbalanced upward pressure of 9926 lb. might cause strains in the piping system at some point or other. Neglecting the weight of the piping entirely and also the weight of the slab, the stress at the floor joint would be only 14,466 ÷ 576 = 25.1 lb. per sq. in., an increase of only 7.8 lb. per sq. in.

If there are four bolts holding the base elbow down to the concrete slab, the strain on each bolt would then be approximately 14,466 — 3000 + 460 ÷ 4 = 2700 lb. and four ¾-in. bolts would be required, each bolt subject to a tensile stress of 2700 ÷ 0.302 = 9000 lb. per sq. in. where 0.302 is the area of a ¾-in. bolt at the bottom of the thread.

Omitting the bolts entirely (not shown on the drawing), the unbalanced upward pressure would be about 10,826 lb. (after deducting the weight of the base elbow and horizontal pipe) and if the elbow were not bolted to the concrete slabs, the difference in pressure caused by a reduction of atmospheric pressure to 0.489 lb. per sq. in. inside the exhaust piping, might cause trouble.

Wherever expansion joints of any kind are used on steam or exhaust lines, due consideration should be given to possible stresses in the piping system and the piping should be securely anchored at the proper point or points to protect the expansion joint.

Woodhaven, N. Y. W. F. FISCHER.

TO CUT BAKELITE or similar tubing with square ends take a piece of paper with a straight edge and wrap two or three times around the tubing to be cut. Square up the edges of the paper and use it as a guide for drawing a line for the saw to follow.

Strainer Casting Repair

FAILURE of the ears holding the clamping bolts of the cover of a strainer furnishing clean lubricating oil to a centrifugal pump unit seemed to spell a shutdown until a replacement could be secured from the factory but by the exercise of some ingenuity the difficulty was surmounted by a pump station staff and operation maintained on schedule.

First ⅜-inch tank plate was roughed out to approximately the desired shape with an acetylene torch and the C-shaped clamp then file fitted to the contour of the strainer body, and drilled to force snugly over the one-inch pins which had originally passed through lugs on the casting to anchor the swivel end of the eye bolts serving to clamp the clean-out covers in place.

Two plates, one on each side of the dual strainer, make it as good as new. Now the tension of one cover clamp bolt, instead of being borne by a comparatively

STEEL C-SHAPED CLAMP REPLACED BROKEN LUGS AND MADE POSSIBLE CONTINUED OPERATION

small sectional area of cast iron, is successfully transmitted through the steel plate to the farther end of the casting as a straight pull without offset leverage, as was the case with the original lugs and there is balanced by the strain set up by the other bolt.

Longview, Texas. ELTON STERRETT.

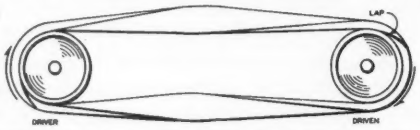
Which Way Should Belt Run?

REFERRING TO the question and answer and the illustration on the above subject, page 1161 of the December 1 number of Power Plant Engineering, the "slip method" for determining the proper method of running the lap is usually best; that is, always run the belt in such a way that the pulley which slips most will smooth out the lap. Air never opens a properly cemented lap. The pulley, usually the small pulley, is what does the damage.

An argument against that method is that some belts open on the outside before opening on the inside owing to the stretching action on the outside of the belt as it is carried over the small pulley, all of which is quite true. Where pulleys are exceedingly small and belts are stiff it is indeed difficut to decide which is the better method. Of course, a pulley should never be too small. A belt should be chosen that will be pliable enough to stand the gaff regardless of pulley diameter. A high grade belt can be used on pulleys as small as 1½ in. in diameter.

Also it should be remembered that on one pulley the belt slips or creeps in one direction and on the other pulley the slip or creep is in the opposite direction. Slipping and creeping are always towards the tight side of the belt; therefore on the first pulley the slip may be such as to smooth the scarfed edge of the joint. Then, any slip on the second pulley would have a tendency to open the joint and cause the feather edge of the lap to roll up.

Herewith is a sketch which shows how, by simply giving one end of the belt a half turn, the tendency will be to smooth the joint on both pulleys—which is as it should be. For wide belts on pulleys that are close together this method is not recommended, but for narrow belts it is all right. Owing to the wide variety of possibilities of drives no rule can be laid down limiting belt width of limiting center distances. I prefer to leave such matters to the belt operator's judgment. It is quite possible that a relationship exists between width, center distance and successful twisting but thus far it has not been formulized.



BELT WITH HALF TURN HAS JOINT SMOOTHED OUT ON BOTH PULLEYS

An advantage possessed by the belt when twisted as shown in the accompanying sketch is that each pulley has its own side of the belt to work on; that is, if it is a single-ply belt the flesh side will always be in contact with one of the pulleys and the hair side will be in contact with the other pulley. Projecting belt fibers therefore are not first bent and rubbed in one direction and then in the other direction, an action which may cause rapid wear. The fibers on both sides of a single belt will lie always in the same direction as the lap—a condition that is ideal. In fact, this advantage holds true regardless of whether the belt is single, double, or triple and whether leather or fabric.

Newark, N. J. W. F. SCHAPHORST.

Diesel Engine Starting Kink

IN POWER plants wherein internal combustion engines drive pumps or compressors through reduction gears with no intervening clutch, trouble is frequently experienced in starting when the unit is cold. Most of this difficulty can be traced to cold lubricant in the reduction gear, which throws an initial friction load on the engine exceeding the power of the starting air.

This trouble may easily be sidestepped altogether if the engine, instead of being "spotted" for starting by being barred over in the direction of normal rotation, be jacked *backward* for more than one full revolution of the engine crankshaft for a two-stroke-cycle unit, or two revolutions for a two-cycle. This will clear the excess grease from the faces of the reduction gears for arcs which will be in contact while the starting air is building up engine speed to the point where the normal firing order can begin.

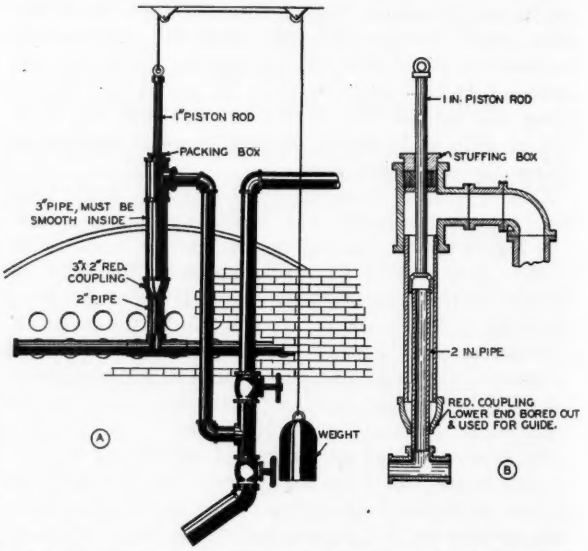
This certainty of starting on the first charge of air when this kink is used more than repays the engineer for the additional trouble entailed by jacking the engine backward as suggested.

Longview, Texas. ELTON STERRETT.

Cleaning Boiler Flues

SOMETIME AGO, I read several articles in your paper about cleaning boiler tubes by blowing sand through them. I am enclosing a small circular that describes an effective blower that I invented and had patented. As the selling cost was high, I am not making them now and have no objection if your readers want to make them for their own use. They can do this with a little machine shop help. Material will cost about $12 or $15, depending on where bought.

Operation and construction are apparent from the two drawings. When steam is turned on it passes down through the hollow piston and out to the tubes. At the same time, the unbalanced thrust forces down the piston and the operator holds onto the cable stopping the blower at any row of tubes desired. When down, the steam is shut off, the operator pulls the blowing element back and the counter weight holds it out of the fire.



ARRANGEMENT AND DETAILS OF HALL FLUE BLOWER

Anderson, Ind. C. M. HALL.

Steam Purifier Pressure Drop

IN REFERENCE to an article I wrote, p. 277, March 1 issue, on steam separators or purifiers it has been called to my attention that some of the readers may have misinterpreted this to mean that all separators are likely to clog up.

To correct any such misunderstanding, I would say that several separators on the market are of such design as to be practically immune from clogging from entrained impurities. I believe it advisable, however, to provide gages to check up on this in installations where the steam is very dirty and flowing part of the time at low velocities, as on some evaporators, regardless of the design of separator. HARRY M. SPRING.

DECISION has been handed down by the U. S. Supreme Court that Zeolite water softening equipment as made by the Graver Corpn. and by Graver Tank & Mfg. Corpn. does not infringe the Gans patent No. 1,195,923, as claims 1 and 5 are held invalid. The Graver organization maintains right, therefore, to manufacture and sell Zeolite softeners, without interference.

Plant Operation Problems

Differential Pulley Ratios

A DIFFERENTIAL pulley has one wheel, B, 8 in. in diameter with 25 teeth, the other, A, being 7.68 in. with 24 teeth. An endless hauling chain is used. What must be the pull on the hauling chain to hoist 500 lb. and how many feet of chain must be hauled in to lift the load 1 ft.? A. V. L.

A. With a differential pulley the formula for determining the pull necessary to lift a given weight is, neglecting friction:

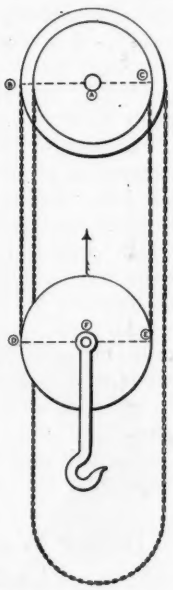


DIAGRAM OF CHAIN TACKLE

$$P = \frac{W \times \frac{1}{2}(AB - AC)}{AB}$$

where

P = force necessary to lift load
W = force lifted (500 lb.)
AB = Radius of larger pulley (4 in.)
AC = Radius of smaller pulley (3.84 in.)

Substituting:

$$P = \frac{500 \times \frac{1}{2}(4 - 3.84)}{4} = 10.5 \text{ lb. necessary to lift the 500-lb. weight.}$$

Consider that the point B of the chain BD moves through an arc whose length equals AB or 4 inches in this case; during the same time the point C or the chain CE will move downward a distance equal to AC because the circumferences of the two circles are directly proportional to their diameters. The length of the loop BDEC will be shortened by AB — AC but the pulley F will be raised only one-half that amount or ½ (AB — AC). The pulley F, therefore, rises ½ (4 — 3.84) for each 4 inches the chain is pulled down, or 0.08 in. Then for each inch the chain is pulled down the pulley will rise

$$\frac{0.08}{4} \text{ or } 0.02 \text{ in.}$$

We can then form the proportion

$$0.02 : 1 :: 1 : X$$

where X is the length of chain pulled down while raising the weight one inch.

$$0.02X = 1$$

$$X = \frac{1}{0.02}$$

$$X = 50 \text{ in.}$$

Or to raise the weight 1 ft., the chain must be pulled down $12 \times 50 = 600$ in. or 50 ft.

What Happens When the Field Switch Opens

WITH TWO alternators operating in parallel with equal load, what happens when the field switch on one of the units is opened? One operator claimed that the kw. remained equal on both units and that the current increased on the unit with the field "in" but that no current was delivered by the unit with the field "out." When this occurred, nothing happened except that the voltage dropped. This, some of us at the plant, attributed to lack of excitation resulting in a weak field. We were operating with a voltage regulator; this had short circuited the exciter field rheostat, doing everything possible to maintain the voltage. The load, at the time this happened, was about 6000 kw. divided equally between two 5000-kw. generators, either of which could have carried the entire load, with all resistance out of the field rheostat and at unity power factor. At the time this condition occurred we had close to unity power factor for the load was mostly lighting.

I would like to know, whether, when a field switch opens as it did in this case, one should close the field switch immediately or open the main generator switch and then parallel the unit again in the usual way. It is my understanding that one would have no trouble either way. Other plants of equal capacity are operating in parallel with us, but during the trouble we lost only 500 kw. The field was out about one minute.

C. D. B.

IN THE 50,000-kw., single shaft turbine recently furnished by Brown, Boveri & Co. for the St. Denis station in Paris, four casings are arranged along the shaft. The first is a high-pressure stage, the second an intermediate stage, the third one of the three low-stage, the fourth the other two low-stage arranged as a double-flow unit. This fourth stage is self-balancing as to end thrust, while the thrust of the single low-stage is nearly balanced by that of the high and intermediate stages. Steam is worked from 781 lb. and 887 deg. F. to vacuum of 28.8 in., the speed being 3000 r.p.m.

New Equipment

High Capacity Steam Trap

FREE FLOATING lever steam traps developed by the Armstrong Machine Works use the inverted bucket principle which insures non air-binding, self-scrubbing and other

ARMSTRONG FREE FLOATING LEVER TRAP

advantages characteristic of this design.

In the illustration, the pencil points to the valve lever which loops over two guide posts at one end and engages the bucket hook at the other. When the bucket floats, it pushes directly against the valve stem, forcing the valve to its seat. Steam presssure within the trap holds the valve against the seat. Water entering the inverted submerged bucket causes the bucket to lose its buoyancy and exert a pull on the end of the lever, the valve opening as soon as the weight of the bucket multiplied by the high leverage is greater than the pressure holding the valve against the seat. When opening, the valve lever fulcrums on the knife edges which bear directly on the valve seat.

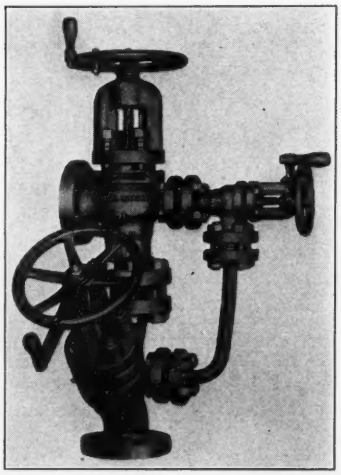
In opening, the bucket increases its pull on the lever until the valve opens. In closing, bucket speed is at maximum as the valve reaches its seat. This high leverage for opening and direct pressure lift for closing reduce strain on the operating mechanism and cause a minimum of wear. Substituting knife edges for pivots largely eliminates friction, also makes it possible to open larger diameter orifices at a given pressure.

Details are: only two moving parts, stainless steel wearing parts, heat treated chrome steel valve parts.

These traps are furnished in cast semi-steel for pressures up to 250 lb. In forged steel they are available for 600, 900 and 1500 lb. pressure with any degree of superheat. The new line includes compound traps for handling large volume of water at any pressure and special traps for pulsating pressure conditions.

Yarway Triplex Blowdown

FOR 1400-LB. pressure service Yarnall-Waring Co. has recently built the combination herewith illustrated to give actual blowdown at high-pressure through a 1-in. valve



TRIPLEX HIGH-PRESSURE BLOWDOWN COMBINATION

while allowing complete washing out at lower pressure through 2½-in. valves. Two main valves are used in series, one angle, the other straightway, both Type C Seatless. To the annular space of each valve, a flanged nozzle is attached and between these is connected a 1-in. Type C angle valve.

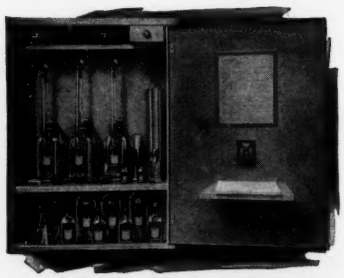
For washing out, the area of a 2 or 2½-in. valve is desired by many engineers but blowing down at 1400 lb. through such valves is troublesome, also great mechanical strains result from such operation; hence operators often merely crack the valves, which results in cutting and leaks. With the combination shown, the outside straightway valve is first opened, then the 1-in. angle valve. The 1-in. valve is closed first, then the 2½-in. straightway. The 2½-in. angle valve is not operated.

Instead of the customary inlet connection at the side, the inlet of the 1-in. valve is under the plunger to avoid the "hydraulic jack" effect which would result if the 1-in. valve were opened while the outside straightway valve was closed.

All three valves have double Alemite fittings for lubrication even while under pressure, yoke springs to maintain constant pressure on the packing, nitralloy plungers and double ball bearings in the stem collar to take the thrust both ways.

Boiler Water Testing Cabinet

IN CONDITIONING boiler water it is important to determine the balance of the water within the boiler



ELGIN WATER TEST SET

so that treatment may be adequate but not needlessly expensive.

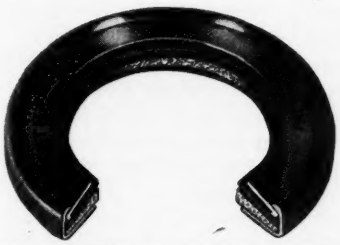
To bring this about, the Elgin Softener Corp. has developed a water test cabinet for measuring the concentration directly in grains per U. S. gallon, with the apparatus and reagents necessary for chemical analysis. The Concentrometer is furnished in a portable case while the reagents, test tubes, flasks, pipettes and burettes are mounted in a steel

cabinet, designed to be hung upon the wall, containing the equipment necessary to make complete examination of boiler water for hardness, hydroxide, alkalinity, carbonates, chlorides, total soluble concentration and suspended matter, with directions for calculating sulphate content and sulphate-alkalinity ratio.

Special sheets or water reports, enable the engineer to watch his water from hour to hour or from day to day and know exactly what treatment is required. Concentration in grains per U. S. gallons determined and the water analysis taken, it becomes simple to determine and maintain the correct balance, sulphate-alkalinity ratio and standardize definitely upon a predetermined concentration.

Oil Seal

AETNA OIL SEAL has been placed upon the market by the Aetna Ball Bearing Mfg. Co., Chicago, Ill. This



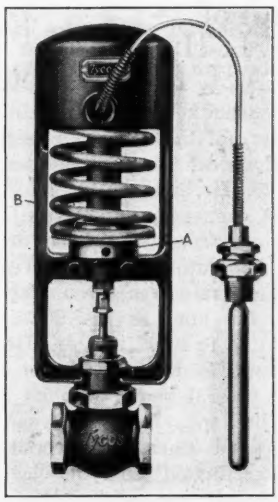
CROSS-SECTIONAL VIEW OF AETNA OIL SEAL

seal consists of four parts, is a self-contained and complete unit which can be slipped in or out of position, with nothing to work loose or become lost. It consists of an outer shell or steel which houses the seal cushion, pressure plate and steel retainer. It is claimed this seal will hold oil as well as grease and will operate without trouble where water is held on one side of the seal and oil on the other. It is interchangeable with all makes of grease seals. Available in sizes from ½ in. inside diameter and up.

Self-Acting Temperature Regulator

USE OF THE self-acting type of regulator has been limited, due to characteristics which made close control and sensitivity difficult but the Taylor Instrument Companies have developed a new accurate and sensitive Tycos self-acting temperature regulator, which opens new fields of use.

In self-acting regulators of the direct bellows and stem-connected type, movement of the valve stem is intended to be proportional to the change in temperature of the bulb so that the position of the valve should always be the same for a



NEW TYCOS TEMPERATURE REGULATOR

given bulb temperature, and the movement in direct relation to changes of bulb temperature. In practice, accomplishment of this ideal is hindered by the element of friction, so that the bulb temperature must be changed several degrees before the valve stem starts to move.

This period, when temperature of the bulb is changing with no resultant stem movement, may be called the "dead period." It may amount to over 10 deg. F. but in the new Tycos regulator, it has been practically eliminated so that the stem moves almost simultaneously with the temperature change.

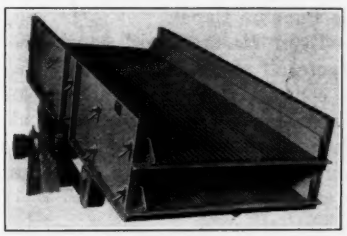
Contributing greatly to the performance of the regulator and its adaptability to the greatest variety of applications is the construction of the tube system, which consists of a double seamless bellows, extra heavy walled copper connection tubing and stainless steel bulb of exceptionally small size and thin wall. This system requires a minimum volume of actuating medium, which makes the small bulb possible and, together with the thin wall and shape of the bulb results in quick response to temperature changes. Construction permits heating the bulb beyond the upper limit of the range of the instrument without injury.

Among the practical applications suggested for the self-acting temperature regulator are bottle and can washers, plating and sealing tanks, hot water service tanks, glue kettles, water storage boxes, hot water circulating systems for vat pasteurizers, drying rooms and open baths.

Heavy-Duty Vibrating Screens

TWO NEW TYPES of vibrating screens have just been announced by Link-Belt Co., Philadelphia, Pa. These are known as Positive Drive Type and Unbalanced Pulley Type, both made with single and multiple decks.

In the Positive Drive Type, the amplitude of vibration is fixed at the factory to suit the work the



DOUBLE DECK, POSITIVE-DRIVE SCREEN

screen is to do. Any given amplitude will cover a wide range of screening surface openings, the angle of inclination, speed of operation and direction of rotation being readily changed at any time to suit the kind, size and condition of material to be screened.

The double deck screen, illustrated, shows the accessibility of the screen cloths which are placed under tension crosswise by side tension members that also serve as wearing plates and prevent material from leaking along the edges. Only the screen cloths need to be removed when replacements are required.

Cantilever leaf springs maintain the screen box at a constant angle, a steel sub-frame regularly furnished being supported from below or hung by cables from above.

The Unbalanced Pulley Type is available for high-speed work where the material is of a sticky nature and on close-sizing problems where

the screen openings are not large. Amplitude of the screen movement can be varied by the user, from zero to about ¼ in., by changing the counterweights in the weight containers. The angle of the screen and the speed and direction of operation can also be changed readily to suit operating conditions.

Dr. Marston Succeeded by Professor Agg at Iowa College

DR. ANSON MARSTON, dean of engineering at Iowa College, Ames, Iowa, will retire from his administrative duties June 30. Dean Marston has been a member of the faculty of the College of Engineering at Iowa for 40 yr., has been dean of engineering for 28 yr. He was president of the American Society of Civil Engineers in 1929 and a member of the Interoceanic Canal Board, appointed by President Hoover to review the proposed Nicaragua Canal and the plans for enlarging the Panama Canal.

Dean Marston will continue to devote all of his time to the college in completing certain culvert and other engineering research, also teach courses in engineering valuation for senior and graduate students in engineering.

He will be succeeded by Prof. T. R. Agg, assistant dean of engineering, who is an electrical engineering graduate of Iowa State College, class of 1905 but has been professor of highway engineering there since 1915. He has been an active member of the Highway Research Board of the National Research Council.

Death of F. L. Hutchinson A. I. E. E. Secretary

FREDERICK LANE HUTCHINSON, secretary of the American Institute of Electrical Engineers, died on Feb. 26. He had been ill before the winter convention of the A.I.E.E. but arose from his sickbed to perform his duties at the convention and the strain was presumably too much for him, as his death was attributed to heart trouble. He was born in Elizabeth, N. J., in 1866. After several years of office work with the Pennsylvania Railroad Co., he entered Cornell University in 1889, graduated from the electrical engineering course in 1893 and entered the Westinghouse Electric & Mfg. Co. Here he worked for several years in manufacturing, engineering and sales departments and then for some time prepared technical literature for the company. In 1901 he was manager of the publication department of C. W. Hunt Co., and later was advertising manager and manager of electrical sales for National Electric Co.

In 1904, Mr. Hutchinson undertook some special work on the transactions of the A.I.E.E. and his work broadened until in 1908 he was made assistant secretary. In 1911 on the resignation of the secretary, Ralph W. Pope, Mr. Hutchinson was made acting secretary and in 1912 national secretary. He served as a member of various important A.I.E.E. committees, as a delegate to the World Power Conferences in London and Tokyo and his work naturally brought his into close contact with all the members of the Institute and with members of other societies. He represented the Institute on the American Engineering Council, the division of engineering and industrial research of the National Research Council and the Engineering Societies library board and was identified with many organizations working for the development of the engineer. He was, of course, a member of the A.I.E.E., also of the American Association for the Advancement of Science, the American Sociological Society and the American Academy of Political and Social Science.

News From the Field

C. O. BARTLETT & SNOW CO., Cleveland, Ohio, announces the transfer of C. W. Ross of the Philadelphia office to New York, where he will be associated with W. H. Norrington, New York manager, in serving the eastern territory.

SARCO CO., Inc., New York, has incorporated a new company, the Spirax Manufacturing Co., Ltd., in London, for the manufacture of steam traps and other specialties for the British market.

NEILAN CO., Ltd. (Division of Mason Co.) and the Mason Regulator Co. announce the establishment of their own joint office at 409 E. Archer Street, Tulsa, Oklahoma, in charge of Gordon Thomason.

MCINTOSH & SEYMOUR CORP. announces a rearrangement of its Eastern and New England Sales Districts. The former, comprising New York, Pennsylvania, New Jersey and Connecticut, is now in charge of H. C. Lenfest, with headquarters at 30 Church St., New York, and the New England District, comprising Massachusetts, Maine, New Hampshire, Vermont and Rhode Island, is in charge of F. C. MacKrell with headquarters also at 30 Church St., New York.

WILLIAM C. DICKERMAN, president of the Montreal Locomotive Works, Ltd., announced that at a meeting of the board of directors on March 2nd, William F. Drysdale was appointed vice-president, sales, and H. C. Butler was appointed vice-president, manufacturing of the organization and all its subsidiaries.

The Montreal Locomotive Works, Ltd., will manufacture and sell self-propelled rail units in accordance with the engineering and specifications of the J. G. Brill Co. of Philadelphia, Pa.; a complete line of process plants and equipment for the oil refining industry, using the patents and processes controlled by Alco Products, Inc., New York City; and a complete line of modern Diesel engines in accordance with the designs and patents of the McIntosh & Seymour Corp., of Auburn, N. Y. At the same time, the works will continue to manufacture and sell steam, electric and Diesel locomotives as heretofore.

HORACE J. HEULINGS, for many years chief engineer of Camden High School, Camden, N. J., died recently. Mr. Heulings was Past Supreme Chief of American Order of Steam Engineers.

NORDBERG MANUFACTURING CO., Milwaukee, Wis., takes pleasure in announcing the affiliation with its present staff of A. E. Ballin, formerly president of McIntosh & Seymour Corp., as vice president in charge of sales and engineering.

C. H. COLLINS has been appointed representative for Chaplin-Fulton Manufacturing Co. of Pittsburgh, Pa. His offices are at 628 Dwight Building, Kansas City, Mo.

ASHTON VALVE CO., Cambridge, Boston, Mass., announces, effective on or about April 15, the removal of its New York offices to 21-23 Albany St. (90 West St. Building).

G. O. FRENCH, who since 1927 has been New York district manager for the Air Preheater Corp., has recently been appointed New York District Sales Manager for the American Smoke & Soot Washer Co., Inc., New York.

BURROWS SLOAN, chairman of the board of the General Refractories Co., Philadelphia, Pa., and a business associate of the late Governor Sproule of Pennsylvania, died on Feb. 28, in his 55th year. Following his graduation from Princeton in 1899, Mr. Sloan was employed by the Reading Co. and later became associated with the Harbison-Walker Refractories Co. in Pittsburgh. In 1911, with Governor Sproule, he organized the General Refractories Co. at Philadelphia. He became president of the company in June, 1925, and was named chairman of the board in April, 1931.

For the Engineer's Library

THE NATURE OF A GAS, by Leonard B. Loeb; cloth, 154 pages, illustrated; size, 6 by 9 in. John Wiley and Sons, Inc., New York, N. Y., 1931; price, $4.25.

This book, it seems to us, fills a long felt need for a discussion of a gas from an electrical standpoint. Ordinarily in thinking of a gas we don't regard it as having anything to do with the laws which underlie the theory of electricity. From our familiarity with modern atomic theory, however, and more recently the researches in electronics, we know that a gas consists of electrical elements, electrons and protons (and today neutrons) and that any fundamental study of gases must rest upon fundamental electrical theory. In order to understand the nature of a gas from an electrical standpoint it is necessary of course to investigate first the nature of the atoms and molecules as units and then to organize their structures and their complex behavior into a whole comprising in its properties the condition of matter known as the gaseous state. This is exactly what Professor Loeb has done. Starting out with a brief historical review of the theory of gases, he introduces the units of electricity and then proceeds to a consideration of atomic and molecular systems. This material is all contained in the first chapter. Chapter 2 presents the kinetic picture of a gas and Chapter 3, the last is devoted to ionization phenomena. It is in this last aspect that the book is most valuable. Gases are used as insulators and occur in insulating materials in a wide variety of conditions. If, therefore, we are to solve the problem of insulation, and dielectrics in the design and operation of electrical equipment, it is necessary first, to be thoroughly conversant with the phenomenon of ionization of gases. This volume, in fact, is the first of a series of monographs to be published under the auspices of the Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council.

Throughout, the material presented is of the most fundamental nature, not only in the study of insulation but of all electrical phenomena. The mechanism of radiation is explained on the basis of the Rutherford-Bohr-Summerfield model of the atom, although the author is careful to warn the reader not to take the models too seriously.

It is unfortunate that a more comprehensive title could not have been chosen. While it is true that the book treats beautifully of the nature of a gas, it does a great deal more, giving a correct and readable account of the present status of theory and fact behind all electrical phenomena. By virtue of its title, many electrical men who would be interested in this book may pass it by.

Professor Loeb is professor of Physics at the University of California.

RELAY HANDBOOK AND SUPPLEMENT. Second Edition; 4½ by 6½ in., 1406 pages, illustrated, durable flexible blue Fabrikoid cover, thintex paper, gold edges. Published by the National Electric Light Association, 420 Lexington Ave., New York, N. Y. 1931. Price $6.00 to non-members.

This, without question is the most comprehensive work on electrical relays that has ever been published, and also, no doubt, the most authoritative. Prepared by the relay subcommittee of the Electrical Apparatus Committee of the National Electric Light Association with the coöperation of the Relay Committee and the Protective Devices Committee of the American Institute of Electrical Engineers, it presents in one compact volume all that is known on the subject today. With the growth of our power systems and with the increasing complexities introduced by large scale interconnection, the question of relay operation has become increasingly important. More and more, the various elements which constitute a system must be guarded against the enormous destructive forces which come into play under conditions of fault, and only the relay is capable of affording this protection. Relay engineering, indeed, is becoming a major branch of electric system practice and this book will be gratefully received by all those interested in relay practice.

The relay handbook was first published in 1926. Since that time, however, many advances have been made in the art and so for two years the preparation of supplementary material to the original edition has been under way. This new material has been combined in one volume with a reprinted edition of the original handbook, thus making available under one cover the latest published information on the subject of relay.

For those who recently have purchased copies of the original Relay Handbook, the supplementary material has been bound in a separate volume with the combined index. This Relay Handbook Supplement is uniform with the combined volume insofar as binding and make-up is concerned but of course is smaller. It has 424 pages and the price to non-members is $3.00.

PRACTICAL MARINE DIESEL ENGINEERING. By Louis R. Ford; second edition, revised and enlarged; cloth, 758 pages, illustrated, size 6 by 9 in.; Simmons-Boardman Pub. Co., 30 Church St., New York; 1931; price, $7.00.

Although written primarily for the operating marine engineer, this book should find application in stationary practice. Following comments on the first edition, description of engine makes was enlarged to include practically every type of marine Diesel engine built today. Intensive development of the two-cycle engine and of supercharging caused the introduction of chapters dealing with these subjects.

Drawing on his long practical experience, the author has included much valuable data on repair and maintenance of the various engine parts and plant auxiliaries. The chapter dealing with the subject of licensing has been rewritten to bring it up to date. This volume is a valuable addition to present day Diesel engine literature.

FOUR BULLETINS of unusual interest to metallurgists and users of plain carbon and alloy steels have recently been published by the Carnegie Institute of Technology, Pittsburgh. Bulletin 51, 15 pages, $0.15, is entitled Method for Electrolytic Extractions of MnO, MnS, FeS and ScO_2 inclusions from plain Carbon Steels. Monometallic inclusions in steels are thought to be the chief causes of steel failures and this new method of determination should throw definite light on the situation. Bulletin 101, 45 pages, $0.50, is in four parts and deals with the alloys of iron, manganese and carbon. These studies of the preparation, thermal analysis, X-ray and dilatometric studies add much to the comparatively small amount of systematic investigation that has been made on the iron-manganese-carbon system. Bulletin 102, 23 pages, $0.25, and Bulletin 103, 40 pages, $0.50, deal with studies of chromium-nickel-iron alloys. The first deals with hardening methods and effects in the stainless range and the second with factors influencing the existence of the metastable phases.

RESEARCH BULLETIN No. 27, issued by the Engineering Experiment Station of Purdue University, is devoted to an oscillographic study of transformer characteristics.

MORRIS SCREW PUMPS, for sewage, condenser circulating water and other large-quantity, low-head applications, are described and illustrated in detail with tables of performance and dimensions in a new bulletin No. 145 of the Morris Machine Works, Baldwinsville, N. Y.

MONEL METAL BOLTS, an outline of their properties, with data on tension, shear, fatigue, ductility and other factors, also diagrams and tables of data, are discussed in detail in Bulletin T-1 recently published by The International Nickel Co., 67 Wall St., New York, N. Y.

IN A RECENT illustrated bulletin, 12 reasons why you save money with Lay-Set preformed wire rope are discussed in detail by the Hazard Wire Rope Co., Wilkes-Barre, Pa.

THE STORY OF NICKEL, by Wm. H. Baldwin, is an interesting 44-p. pamphlet issued by the International Nickel Co., Inc., of New York City. It tells of the development of extraction of nickel from the ore, of the adaptation of nickel and its alloys for use in the arts and industries and of the present methods of nickel extraction, the manufacture of monel metal and other activities of the International Nickel Co.

IN BULLETIN 401, Mason Regulator Co., 1190 Adams St., Boston, Mass., announces and describes a new non-recording pressure controller for process industries. It has balanced compound pilot valve, permitting remote control, simplified adjustment and gives uniform steps of movement of the diaphragm control valve for definite movements of the control element, providing straight line functioning.

REPUBLIC CO_2 METERS, their construction, principles of operation and applications are discussed in a letter-size, 24-page attractively illustrated Catalog No. 401, just issued by Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill. Of special interest are the artistic photographs of the instruments, illustrating the detailed descriptions. Principles of operation, methods of installing filter and meter and combustion losses and methods of preventing them are treated in detail.

STANDARD and Sanitary Pumps Parts List has just been issued by The Viking Pump Co., Cedar Falls, Iowa.

GAGE VALVES and the use of Edward valves on Diesel engines are described in leaflets issued by the Edward Valve & Mfg. Co., East Chicago, Indiana.

Power Plant Construction News

Ala., Birmingham—Avondale Mills, Birmingham, plan installation of electric power equipment in connection with an expansion and improvement program at cotton mills, entire project reported to cost over $300,000. Donald Comer is president and treasurer.

Calif., San Francisco—Pacific Gas & Electric Co., 245 Market Street, plans installation of compressor plants for high pressure service, in connection with new natural gas transmission line from Milpitas to San Francisco, about 45 mi., entire project including pipe line to cost close to $1,800,000.

Conn., New Britain—Southern New England Ice Co., 48 Edward Street, Hartford, Conn., is said to be planning construction of a new ice-manufacturing plant at New Britain, reported to cost over $30,000, with equipment.

Conn., West Haven—Hygienic Ice Co., State Place, plans construction of a one-story ice-manufacturing plant, 57 x 85 ft., on Elm Street, near First Avenue, reported to cost close to $25,000, with equipment.

Fla., Jacksonville—Board of City Commissioners is considering the construction of a transmission line from main power plant on Tallyrand Avenue, to power substation on Laura Street, estimated to cost close to $75,000.

Ill., Chicago—Chicago Union Station Co., Union Station, has filed plans for a multi-story power plant, 94 x 116 ft., at 301-11 West Taylor Street, estimated to cost $295,000. Graham, Anderson, Probst & White, 80 East Jackson Boulevard, are architects.

Ill., Chicago—United States Engineer Office, First District, Chicago, is asking bids (no closing date stated) for electrical equipment for Dresden Island and Brandon Road locks, as per specifications on file.

Ill., Lake Forest—City Council is considering extensions and improvements in pumping plants and coagulating system for municipal waterworks, reported to cost about $25,000. James F. King is city clerk.

Iowa, Perry—City Council has tentative plans under way for a water filtering plant for municipal water system, estimated to cost about $30,000. Howard R. Green Co., Bever Building, Cedar Rapids, Iowa, is consulting engineer.

Iowa, Sumner—City Council is having plans completed for a municipal electric light and power plant, and contemplates early call for bids. Estimates of cost being made. H. J. Cory, Redick Tower Building, Omaha, Neb., is consulting engineer.

Ky., Paris—City Council has tentative plans under way for a municipal electric light and power plant. Estimates of cost will soon be made. Black & Veatch, Mutual Building, Kansas City, Mo., are consulting engineers.

La., Gretna—Davison-Pick Fertilizers, Inc., Gretna, plan installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire, with loss reported over $150,000.

Md., Baltimore—City of Baltimore will soon receive bids for construction of new boiler house to take care of approximately 1500 Hp. at City Hospitals, Eastern Avenue Extension.

Mass., Great Barrington—Lincoln H. Smith, Egremont Plain Road, Great Barrington, is at the head of a project to construct and operate an ice-manufacturing plant, in vicinity of Lake Mansfield. Estimated cost not announced.

Mass., Worcester—Tatnuck Ice Co., Broodside Avenue, has filed plans for a one-story ice-manufacturing plant, reported to cost close to $30,000, with equipment.

Mo., St. Joseph—Dugdale Packing & Cold Storage Co., R.F.D. No. 5, has authorized construction of a cold storage unit, in connection with one-story and basement packing plant, entire project to cost close to $40,000.

Mo., Washington—City Council is considering tentative plans for a municipal electric light and power plant and distributing system. Estimates of cost will soon be made. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Mont., Hamilton—Fred T. Parker, Hamilton, plans construction of coal storage and refrigerating plant, in connection with a new canning factory, entire project reported to cost over $75,000. R. C. Hugenin, 1923 West Porphy Street, Butte, Mont., is architect.

Neb., Omaha—Metropolitan Utilities District, Eighteenth and Harney Streets, C. D. Robinson, chief engineer, will take bids at once for gas purifier equipment, with capacity for eliminating sulphuric impurities from 20,000,000 cu. ft. of gas per day, reported to cost about $60,000. Also proposed to build an addition to present water purification plant.

Neb., Omaha—Nebraska Consolidated Mills, 1521 North Sixteenth Street, plans installation of electric power equipment in proposed new five-story flour mill, entire project reported to cost over $100,000. Horner & Wyatt, Board of Trade Building, Kansas City, Mo., are consulting engineers.

N. J., Salem—Mannington Mills, Inc., Salem, plans installation of electric power equipment in new textile mill buildings, comprising several one-story structures, entire project reported to cost over $75,000. Louis H. Goettleman, 402 Chestnut Street, Brooklawn, N. J., is architect.

N. C., Asheboro—McCrary Hosiery Mills, Inc., Asheboro, plan installation of electric power equipment in new two-story mill, 102 x 140 ft., entire project to cost over $150,000. D. B. McCrary is president.

Ohio, Cleveland—Cleveland Wax Paper Co., 13831 Triskett Road, N. W., plans installation of electric power equipment in proposed new addition to plant, reported to cost close to $40,000. A. J. Trumbull is president.

Ohio, Cleveland—Industrial Rayon Corporation, 9801 Walford Avenue, plans installation of electric power equipment in group of new plant buildings, entire project to cost more than $200,000. Christian, Schwarzenberg & Gaede Co., Union Building, is architect and engineer.

Ohio, Uhrichsville—City Council is considering installation of a municipal electric light and power plant. Estimates of cost will soon be made. J. W. Lytle, mayor, is at head of project.

Okla., Cyril—Anderson-Prichard Oil Corporation, Oklahoma City, plans installation of pumping machinery, tanks, power equipment, etc., in connection with proposed rebuilding of oil refining plant at Cyril, recently destroyed by fire with loss approximating $85,000.

Okla., Okmulgee—Independent Ice Co., Seventh Street and Okmulgee Avenue, has leased local building and will remodel and equip for a new ice-manufacturing plant, with capacity of about 25 tons per day.

Pa., Saxton—Broad Top Coal Operators' Association, C. F. Zimmerman, First National Bank Building, Huntingdon, Pa., president, plans construction of mechanical coal-cleaning, sizing and distributing plant in vicinity of Saxton, for metallurgical coal production, reported to cost more than $300,000.

Que., Montreal—National Quarries, Ltd., Montreal, plan installation of electric power equipment at proposed new quarry development at Cote St. Michel, Island of Montreal, entire project to cost over $1,000,000.

Texas, Houston—Earth Products Co., Sterling Building, recently organized with capital of $300,000, plans installation of electric power equipment in proposed new non-metallic mineral processing plant on local site, entire project reported to cost over $75,000. W. W. Rodgers is president.

Utah, Ogden—Utah State Building Commission, Capitol Building, Salt Lake City, is considering construction of a new steam power plant at School for Deaf and Blind, Ogden, for central heating service, estimated to cost close to $50,000.

Va., Kilmarnock—Ditchley Fertilizer Co., Kilmarnock, plans installation of electric power equipment, in connection with proposed rebuilding of portion of factory, recently destroyed by fire with loss reported close to $125,000.

W. Va., Chester—E. C. Otis Mfg. Co., Toronto, Ohio, plans installation of electric power equipment in proposed new roofing manufacturing plant at Chester, entire project reported to cost about $65,000.

W. Va., Chester—C. A. Smith, Jr., Chester, and associates plan installation of electric power equipment in new ebonite plant. Former local factory of Cord Tire Co., will be remodeled and equipped. A company is being organized to carry out project, which is estimated to cost $100,000.

Wis., Kaukauna—Thilmany Pulp & Paper Co., Kaukauna, is said to be planning installation of electric power equipment in new addition to plant for paper bag manufacture, entire project reported to cost over $80,000.